

Figure 1: Communications Channel Definitions

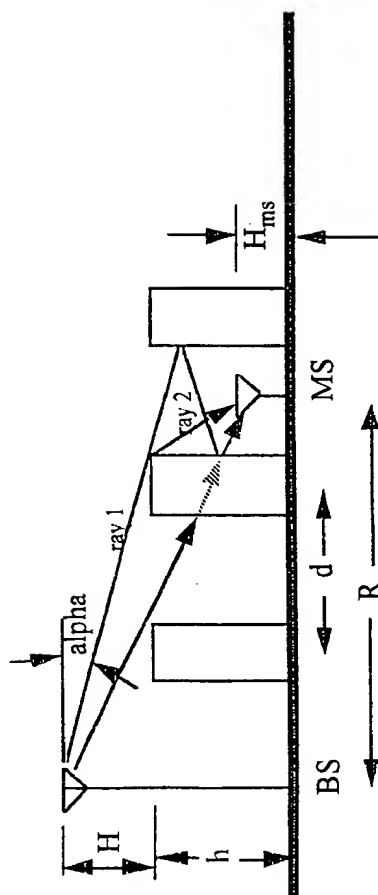


Figure 2: Various ray paths with building presence

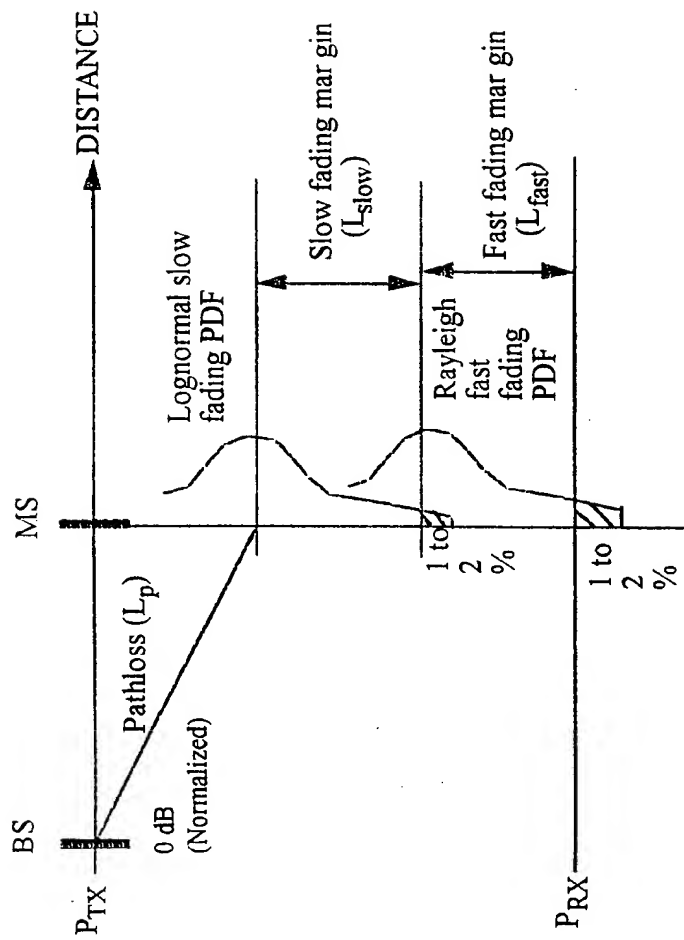


Figure 3: Statistical Power Budget Design

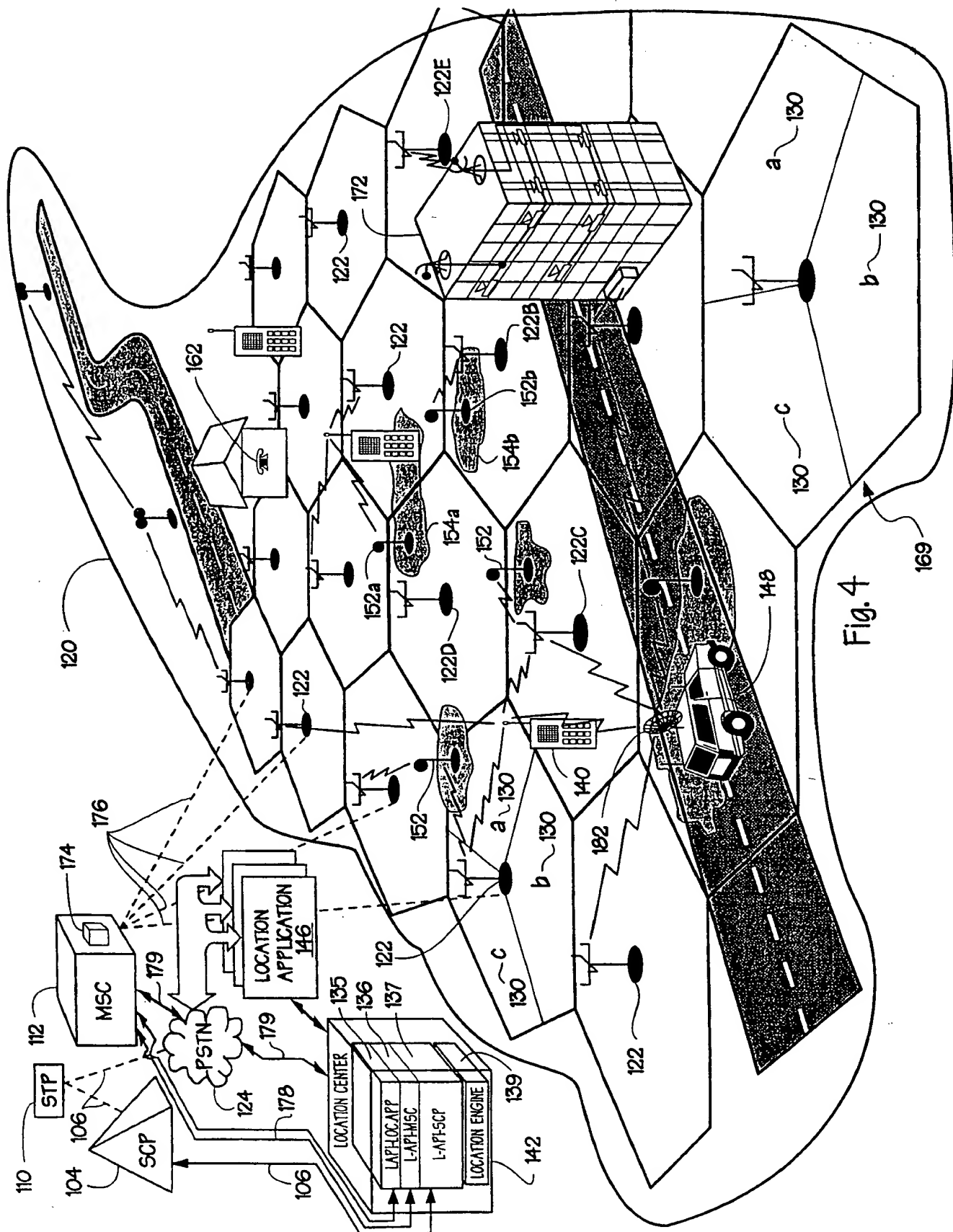


FIG. 5

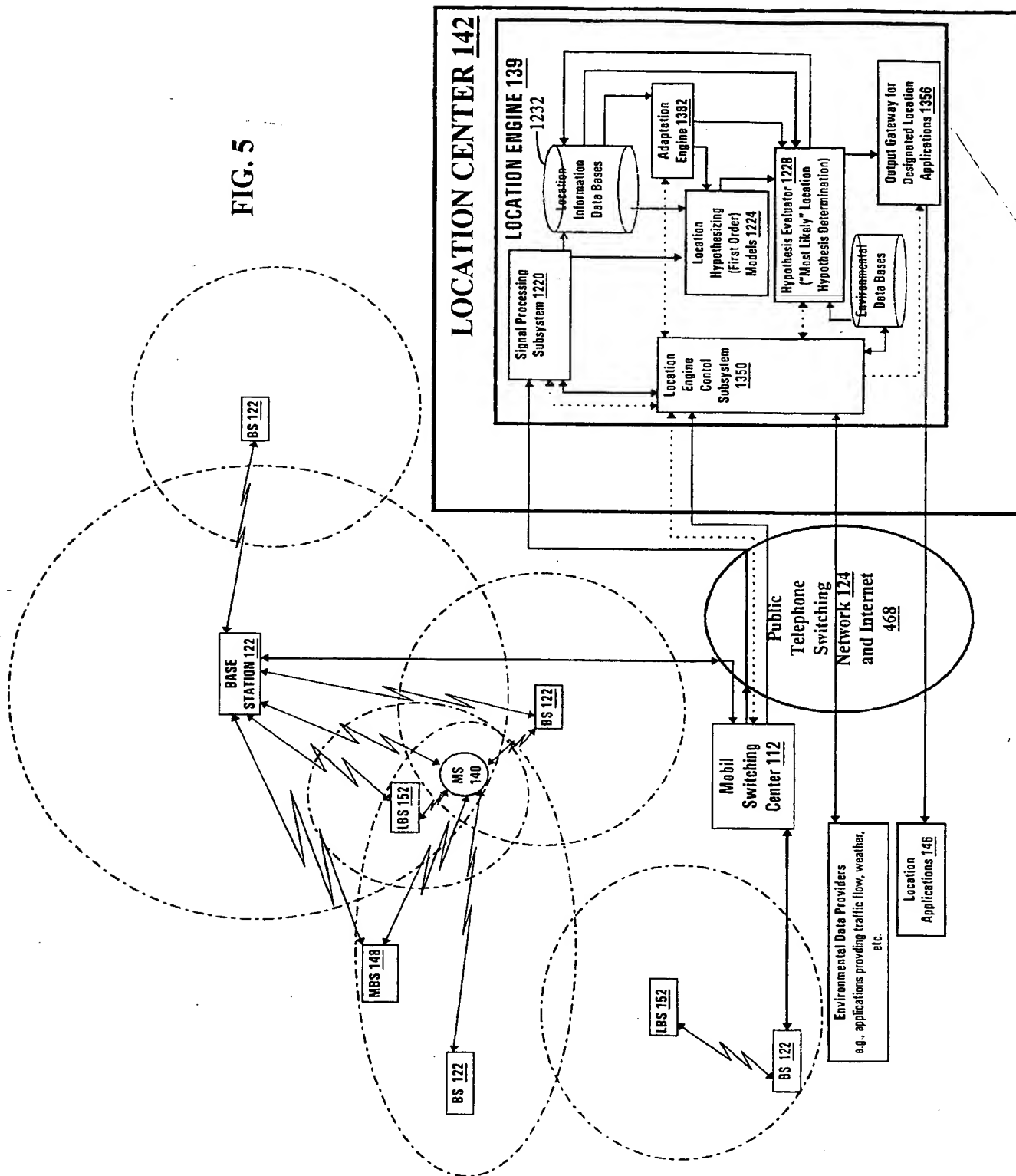
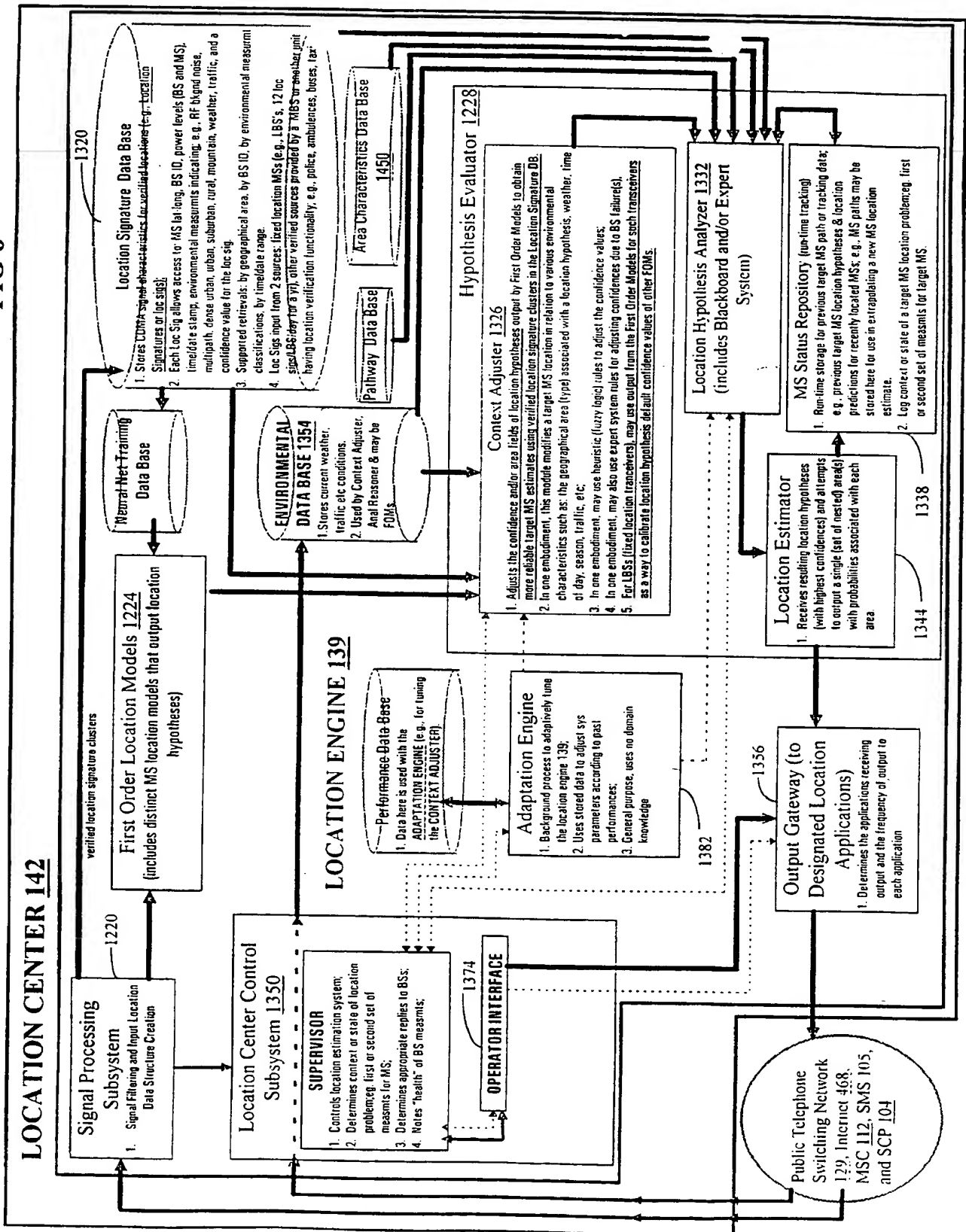


FIG 6



Control flows are thin arrows, major data flows are thick arrows.

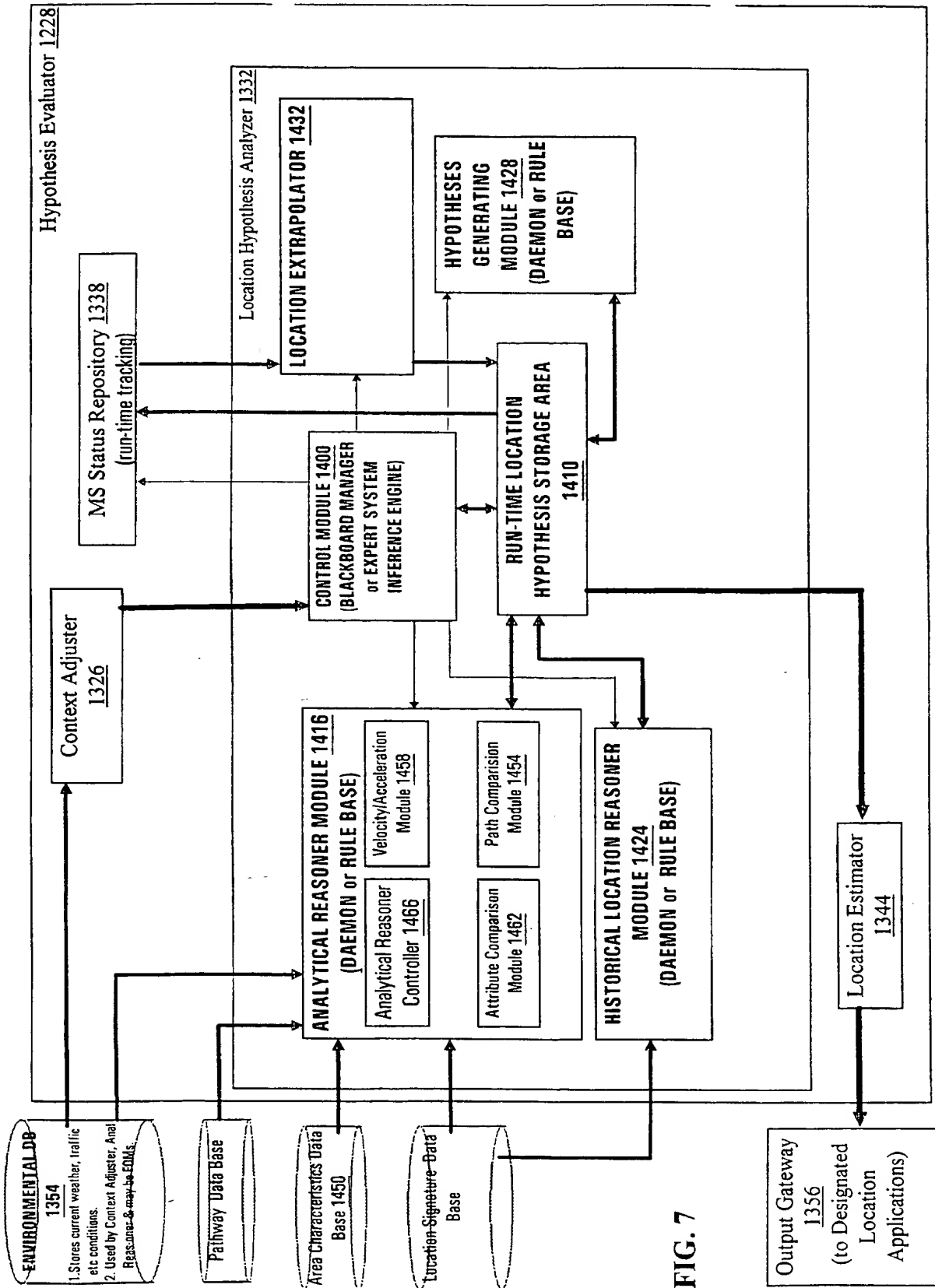


FIG. 7

**FIG. 8**

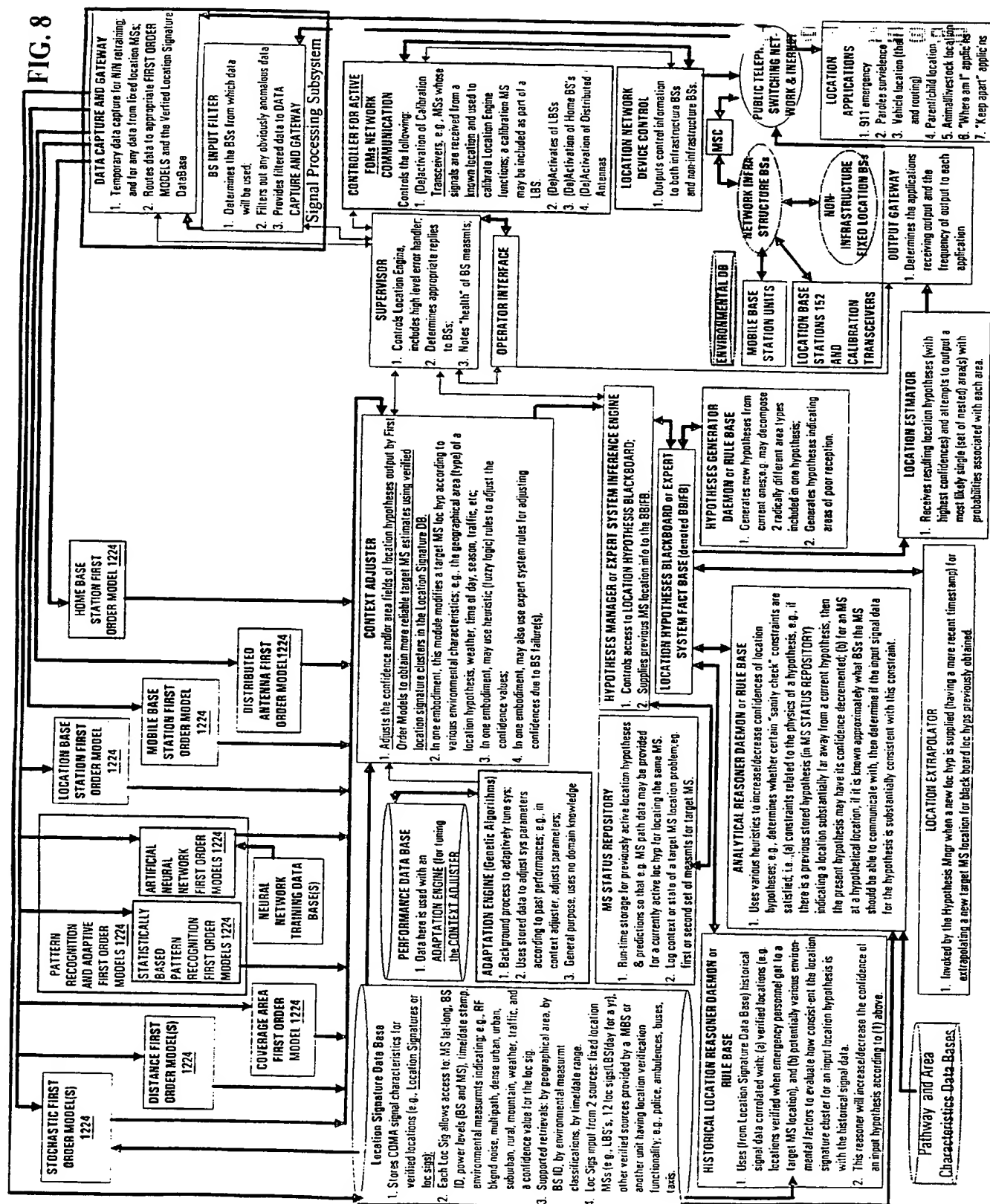




FIG. 9

## DATA STRUCTURE FOR A LOCATION HYPOTHESIS

**FOM\_ID:** First Order Model ID (providing this Location Hypothesis); note, since it is possible for location hypotheses to be generated by other than the FOM's, in general this field identifies the module that generated this location hypothesis.

**MS\_ID:** The identification of the target MS to which this location hypothesis applies.

**pt\_est:** The most likely location point estimate of the target MS

**valid\_pt:** Boolean indicating the validity of "pt\_est"

**area\_est:** Location Area Estimate of the target MS provided by the FOM. This area estimate will be used whenever "image\_area" below is NULL.

**valid\_area:** Boolean indicating the validity of "area\_est" (one of "pt\_est" and "area\_est" must be valid).

**adjust:** Boolean (true iff adjustments to the fields of this location hypothesis are to be performed in the Context Adjuster Module)

**pt\_covering:** reference to a substantially minimal area (e.g., mesh cell) covering of "pt\_est". Note, since this MS may be substantially on a cell boundary, this covering may in some cases include more than one cell.

**image\_area:** reference to an area (e.g., mesh cell) covering of the image cluster set area for "pt\_covering" (see detailed description of the function, "confidence\_adjuster"). Note that if this field is not NULL, then this is the target MS location estimate used by the Location Center instead of "area\_est".

**extrapolation\_area:** reference to (if non-NULL) an extrapolated MS target estimate area provided by the Location Extrapolator submodule of the Hypothesis Analyzer. That is, this field, if non-NULL, is an extrapolation of the "image\_area" field if it exists, otherwise this field is an extrapolation of the "area\_est" field. Note other extrapolation fields may also be provided depending on the embodiment of the present invention, such as an extrapolation of the "pt\_covering".

**confidence:** A real value in the range [-1.0, +1.0] indicating a likelihood that the target MS is in (or out) of a particular area. If positive: if "image\_area" exists, then this is a measure of the likelihood that the target MS is within the area represented by "image\_area," else if "image\_area" has not been computed (e.g., "adjust" is FALSE), then "area\_est" must be valid and this is a measure of the likelihood that the target MS is within the area represented by "area\_est." If negative, then "area\_est" must be valid and this is a measure of the likelihood that the target MS is NOT in the area represented by "area\_est". If it is zero (near zero), then the likelihood is unknown.

**Original\_Timestamp:** Date and time that the location signature cluster for this location hypothesis was received by the CDMA Filter Subsystem,

**Active\_Timestamp:** Run-time field providing the time to which this location hypothesis has had its MS location estimate(s) extrapolated (in the Location Extrapolator of the Hypothesis Analyzer). Note that this field is initialized with the value from the "Original\_Timestamp" field.

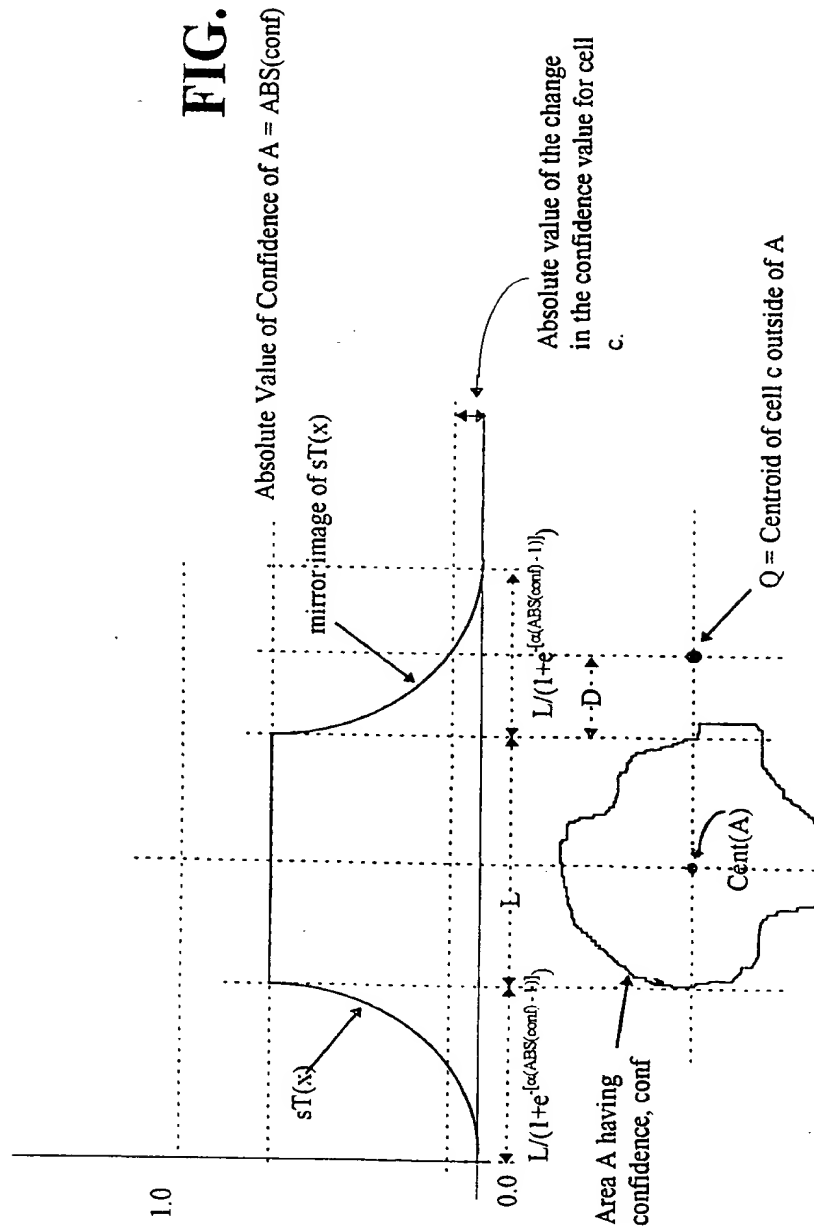
**Processing Tags and environmental categorizations:** For indicating particular types of environmental classifications not readily determined by the Original\_Timestamp field (e.g., weather, traffic), and restrictions on location hypothesis processing.

**loc\_sig\_cluster:** Access to location signature signal characteristics provided to the First Order Models by the CDMA Filter Subsystem; i.e., access to the "loc sigs" (received at "timestamp" regarding the location of the target MS)

**descriptor:** Optional descriptor (from the First Order Model indicating why/how the Location Area Estimate and Confidence Value were determined)

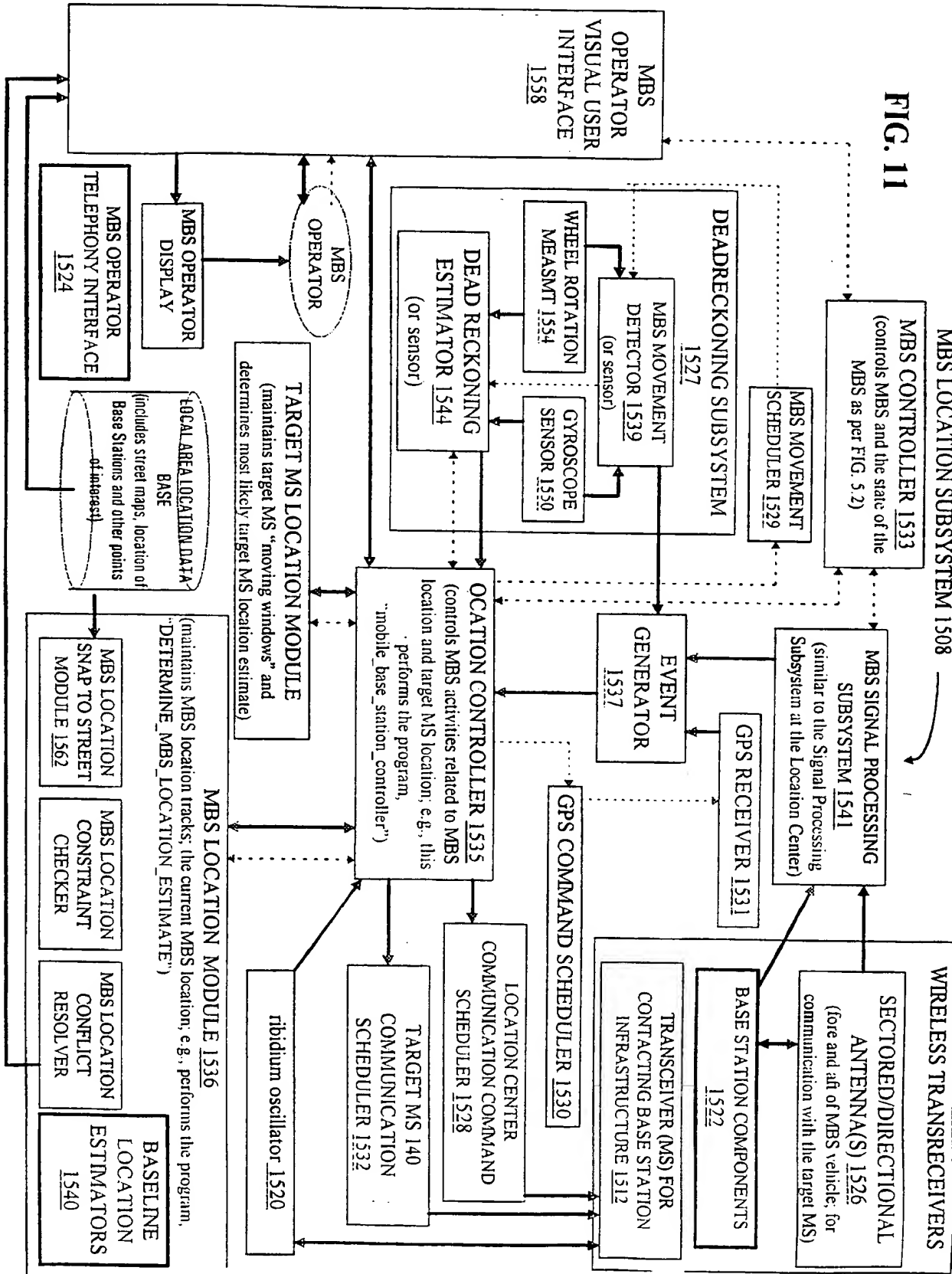
10/54

FIG. 10



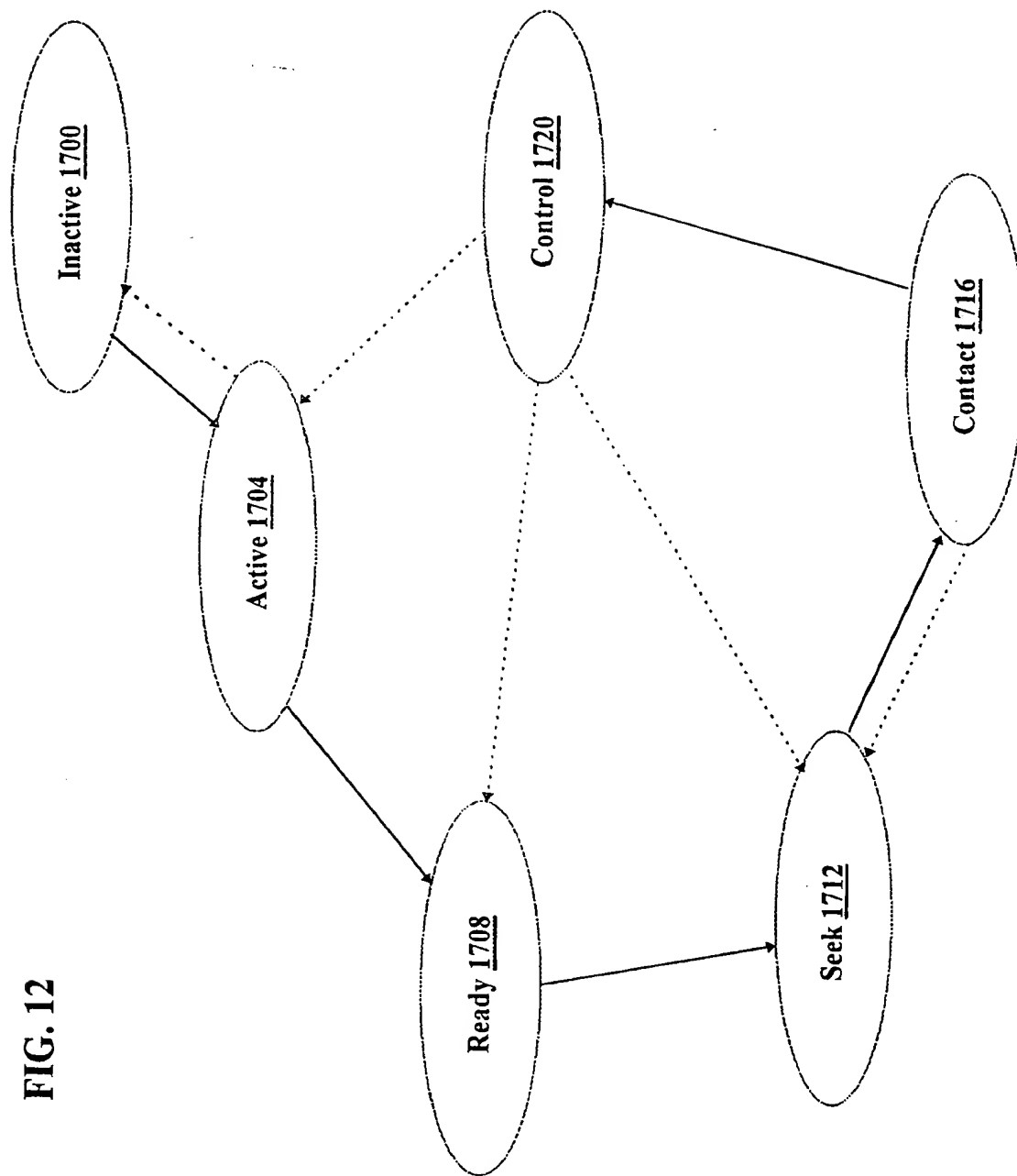
11/54

FIG. 11

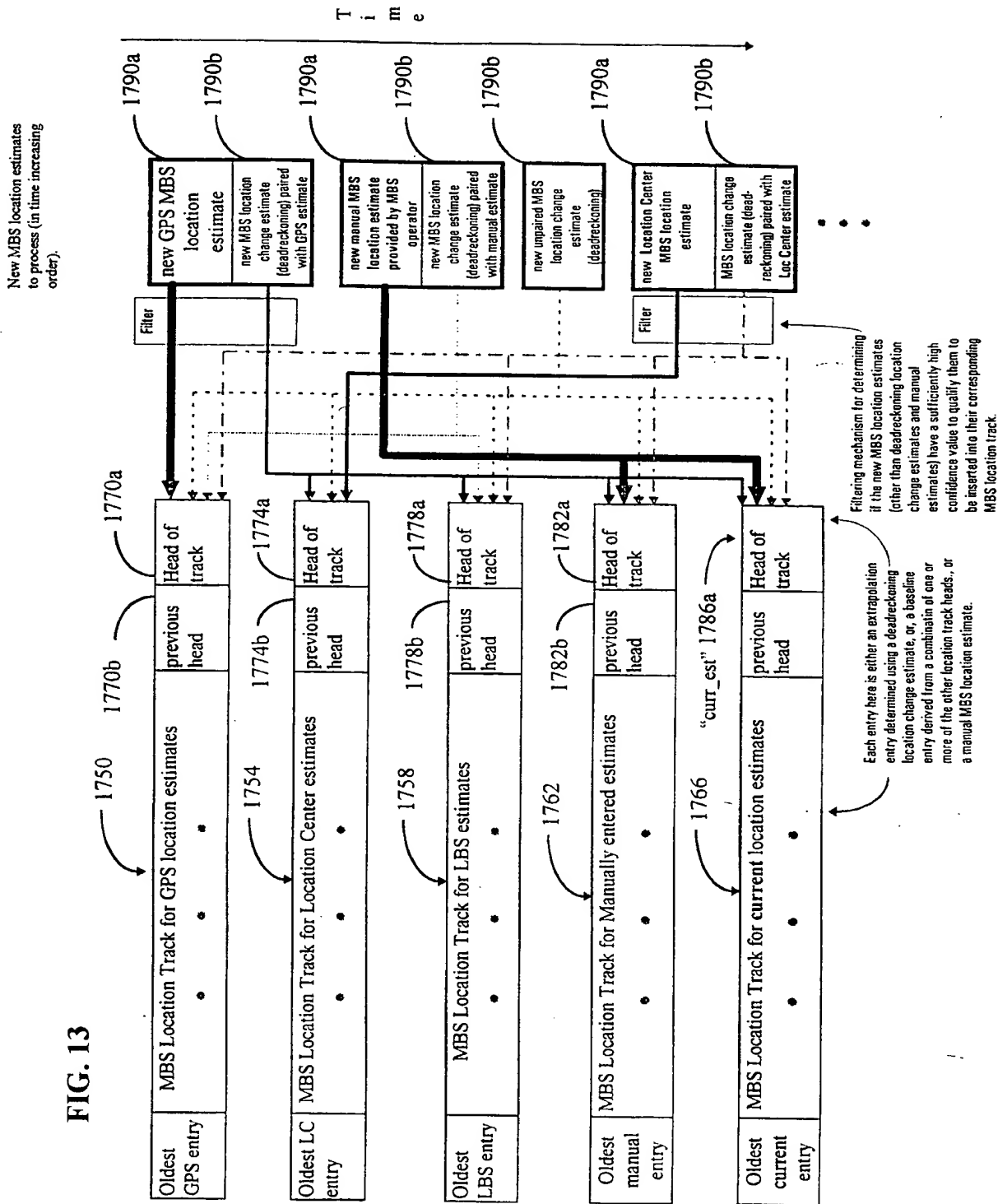


001044367-111100

12/54



SECRET 29241650



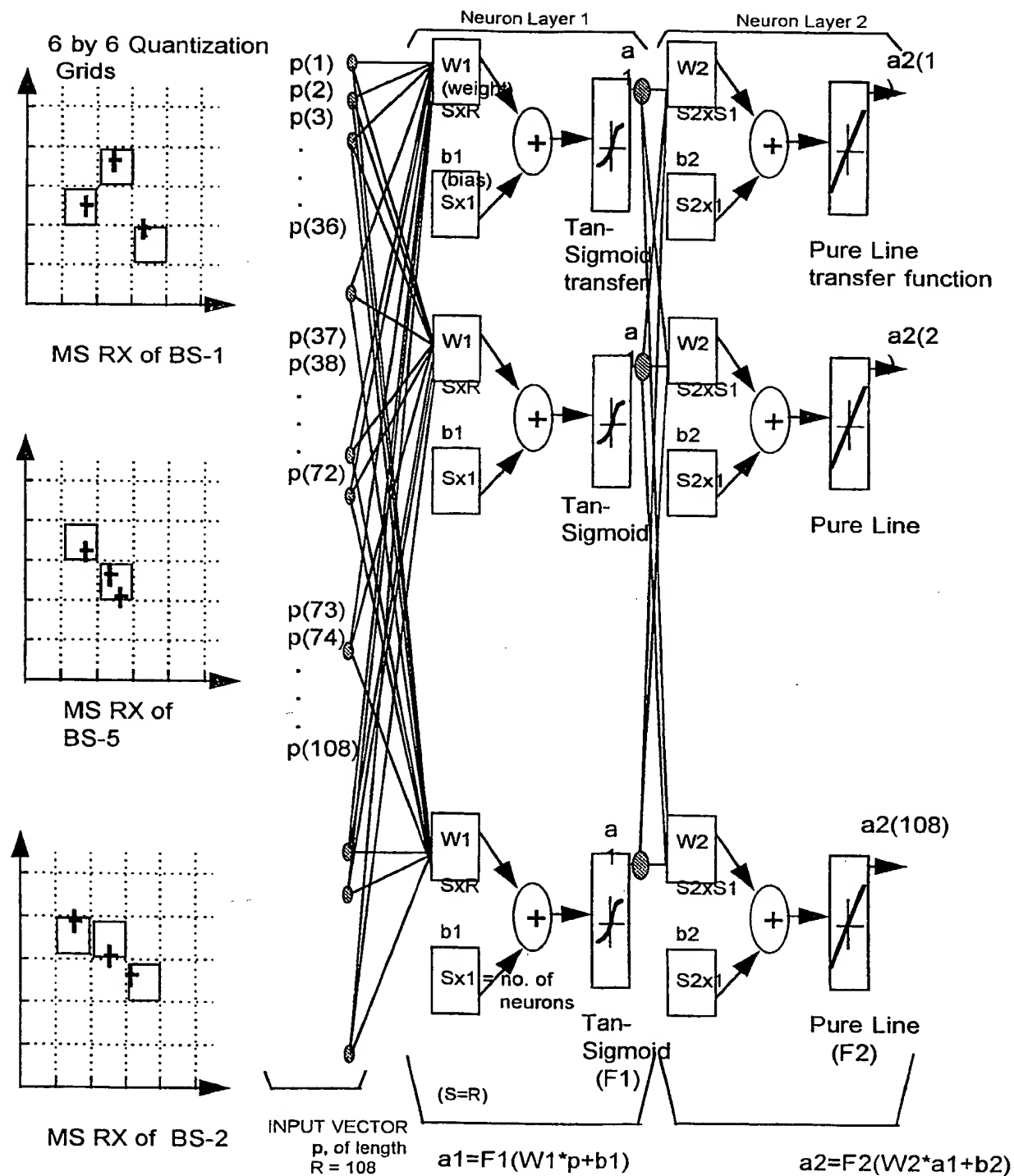


Figure 14: Neural Network Architecture: 2 of 3 Layers shown  
(Dense Urban Canyon)

SECRET - UNCLASSIFIED

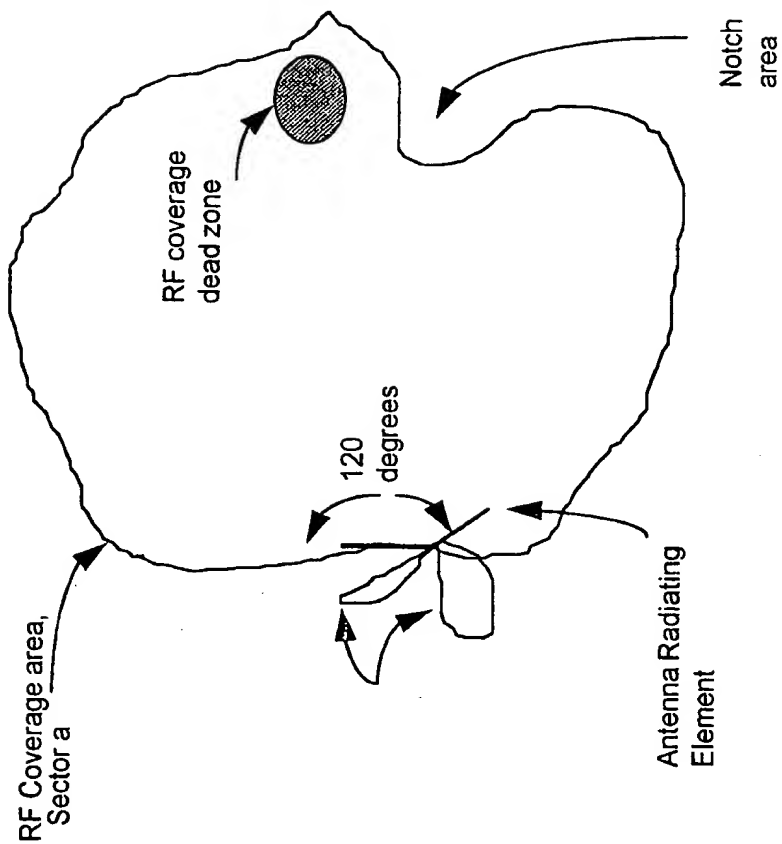


Figure 15: Typical Single-Sector Radiator Pattern, with Dead Zone and Notch

Fig. 16a

### Location Signature Data Type

**MS\_type:** The make and model of the target MS 140 associated with a location signature instantiation;

**BS\_id:** An identification of the base station 122 (location base station 152) communicating with the target MS;

**verified\_flag:** TRUE iff a location of MS\_loc has been verified, FALSE otherwise. Note, if this field is TRUE (i.e., the loc sig is verified), then the base station identified by BS\_id is the current primary base station for the target MS;

**MS\_loc:** If verified\_flag is TRUE, then this attribute includes an estimated location of the target MS.  
If verified\_flag is FALSE, then this attribute has a value indicating "location unknown".

Note this attribute may include the following two subfields: an area within which the target MS is presumed to be, and a point location (e.g., a latitude and longitude pair) where the target MS is presumed to be (in one embodiment this is the centroid of the area);

**confidence:** a value indicating how consistent this loc sig is with other loc sigs in the location signature data base 1320; the value for this entry is in the range [0, 1] with 0 corresponding to the lowest (i.e., no) confidence and 1 corresponding to the highest confidence;

**timestamp:** The time and date when the location signature was received by the base station of BS\_id;



**Fig. 16b**

signal topography characteristics:

Characteristics of a generated surface(s), the surface(s) being generated by the signal filtering subsystem 1220 using signal measurements between the MS and BS associated with the loc sig, wherein the measurements were accumulated over a particular (relatively short) time interval. For example, the dimensions for the generated surface may be signal strength and time delay. By sampling such signal characteristics and tallying the samples in each of a plurality of mesh cells, a mountainous surface can be obtained. Such a surface, is believed, under most circumstances, to provide a contour that is substantially unique to the location of the target MS 140. The attributes of such a surface(s) retained in the signal topography characteristics here include, for example: for each local maximum (of the surface) above a predetermined noise ceiling threshold, the (signal strength, time delay) coordinates of the cell of the local maximum and the corresponding height of the local maximum. Additionally, certain gradients may also be included for characterizing the "steepness" of the surface mountains. Moreover, in some embodiments, a frequency may also be associated with each local maximum. Thus, the data retained for each selected local maximum can include a quadruple of signal strength, time delay, height and frequency;

quality\_obj: This object includes one or more signal quality (or error) measurements (e.g., Eb/No values);

noise\_ceiling: Noise ceiling values used in the initial filtering of noise (by the signal filtering subsystem 1220) from the surface(s) used in generating the signal topography characteristics;

**Fig. 16c**

power\_level: The power levels of the associated BS 122 and MS 140 for the signal data used for this loc sig;  
timing\_error: An estimated (or maximum) timing error between the associated base station (e.g., an infrastructure base station 122 or a location base station 152) detecting the associated target MS 140 and the current primary BS 122 for this target MS. Note that if the BS 122 associated with the loc sig is the primary base station (e.g., when the loc sig is verified), then the value here will be zero;  
cluster\_ptr: A pointer to the location signature cluster to which this loc sig belongs.

19/54

UPDATE\_LOC\_SIG\_DB(NEW\_LOC\_OBJ, SELECTION\_CRITERIA, LOC\_SIG\_POP)

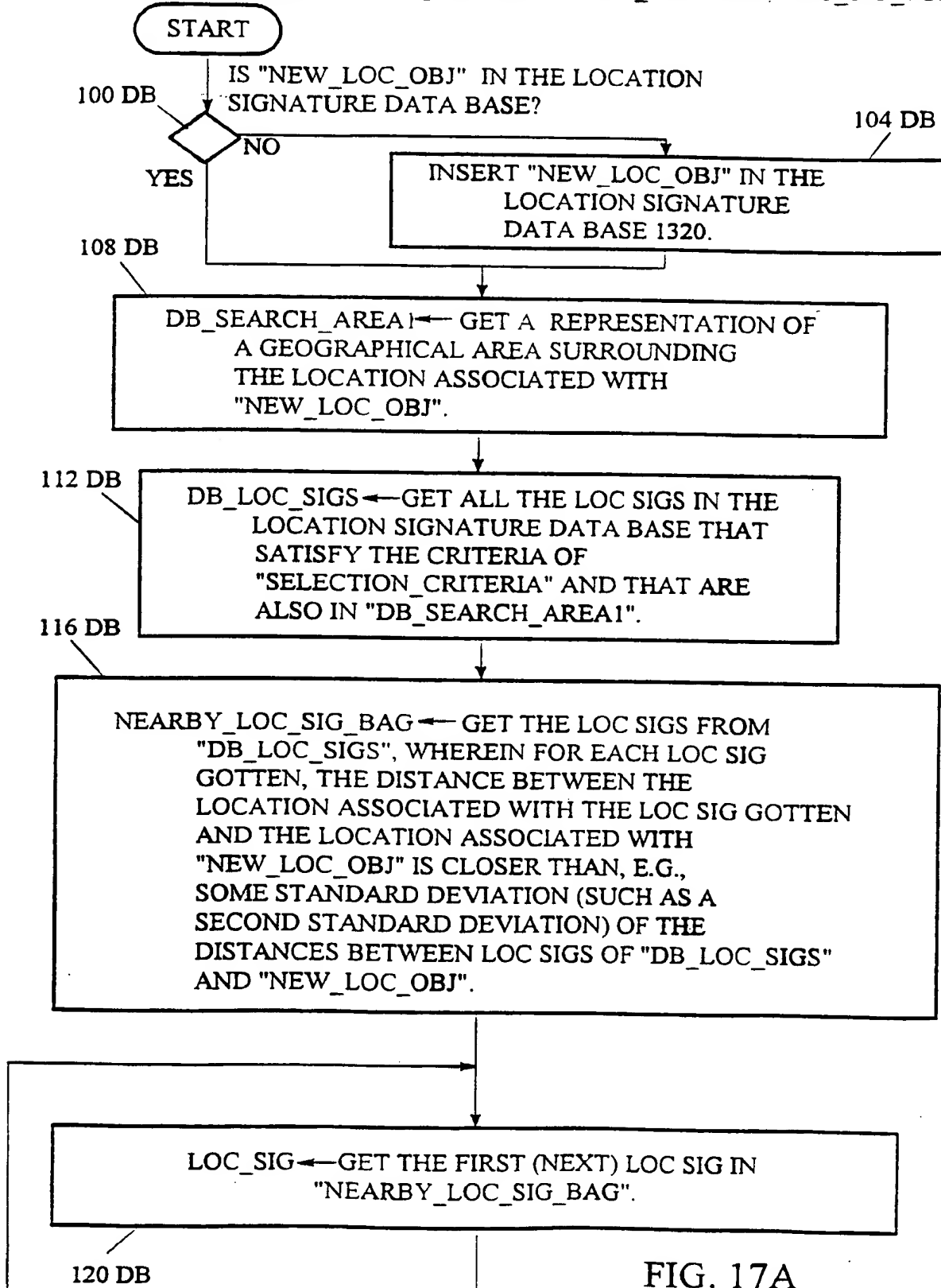


FIG. 17A

20/54

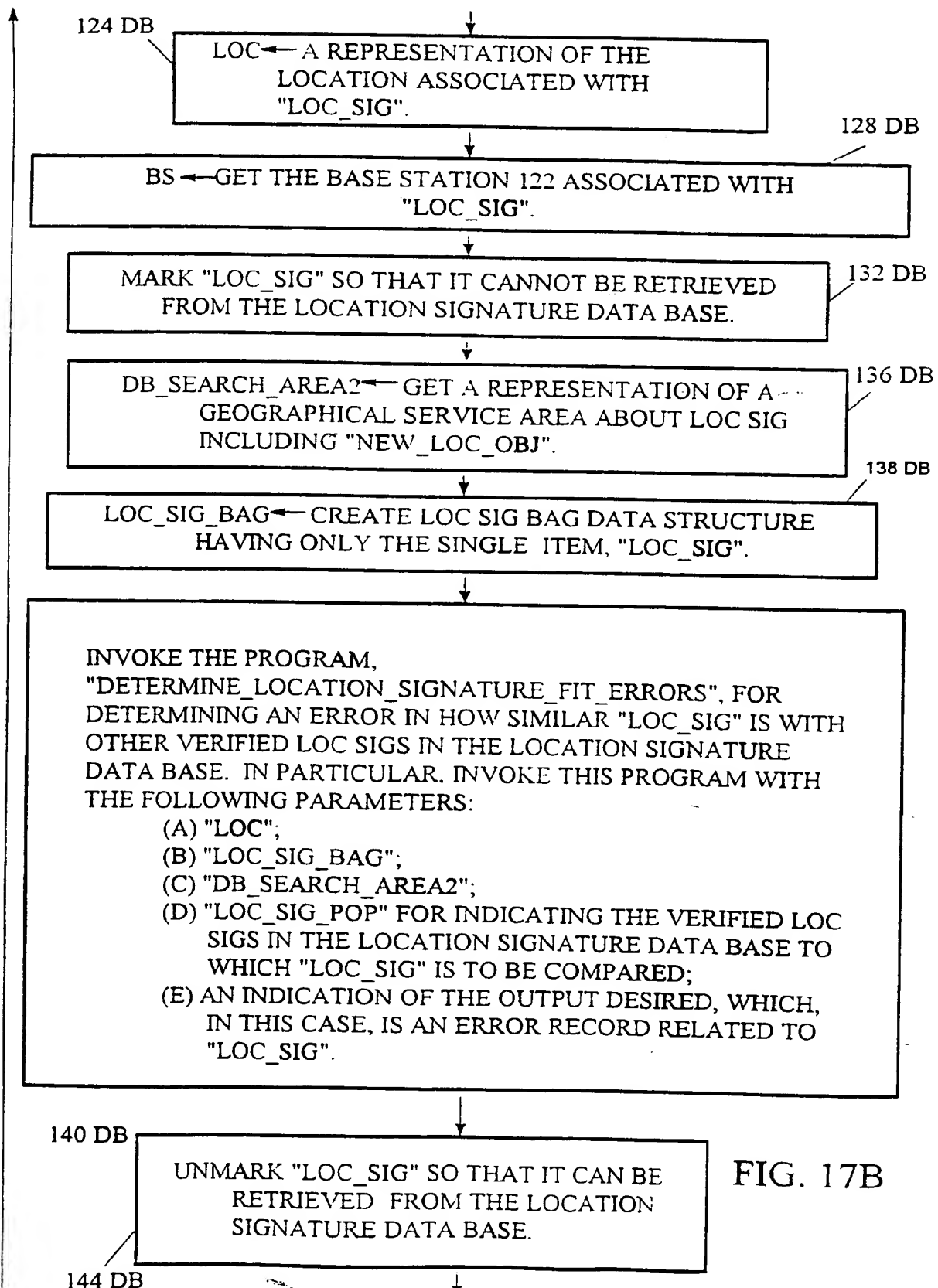


FIG. 17B

21/54

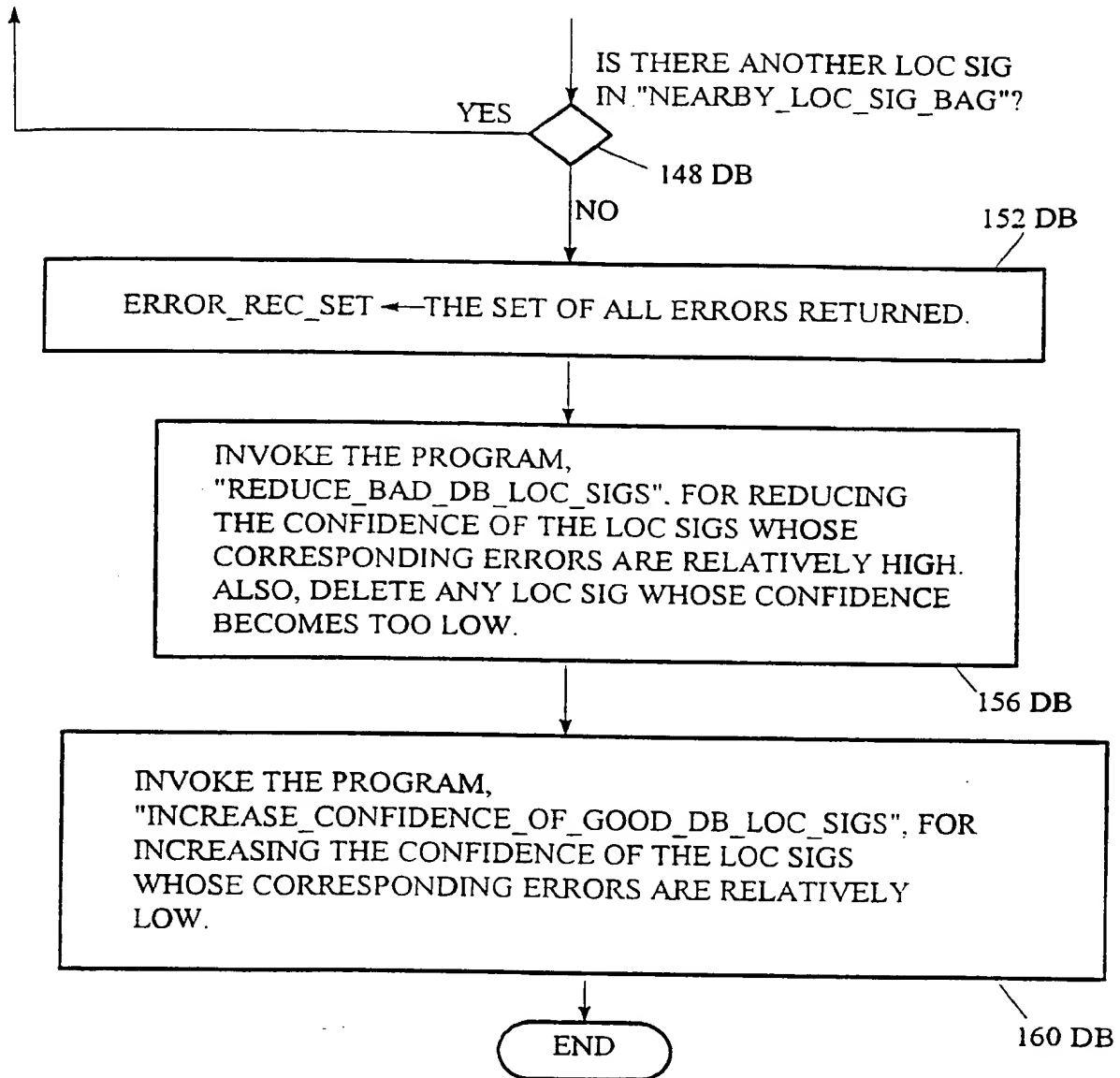


FIG. 17C

REDUCE\_BAD\_DB\_LOC\_SIGS(LOC\_SIG\_BAG)

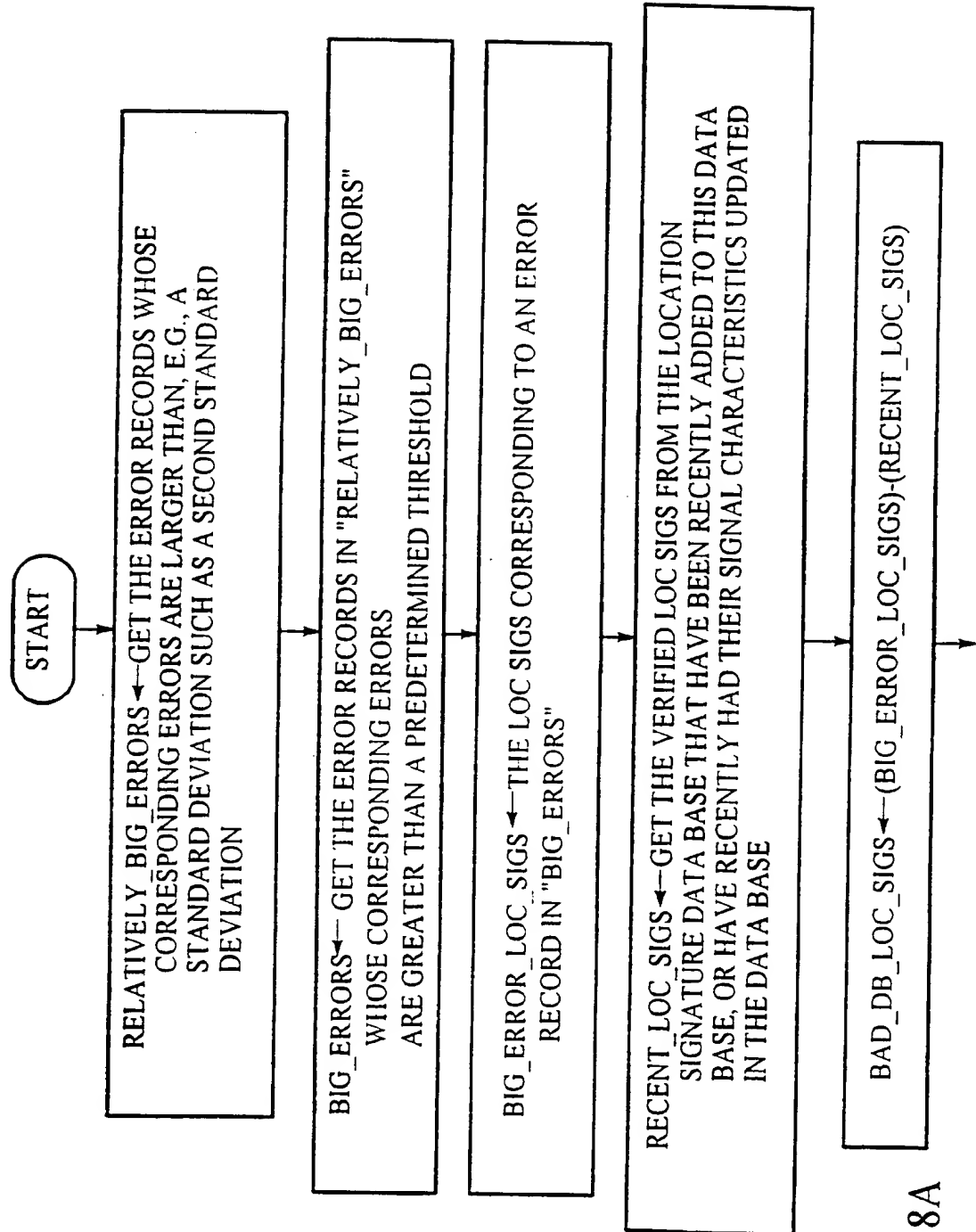


FIG. 18A

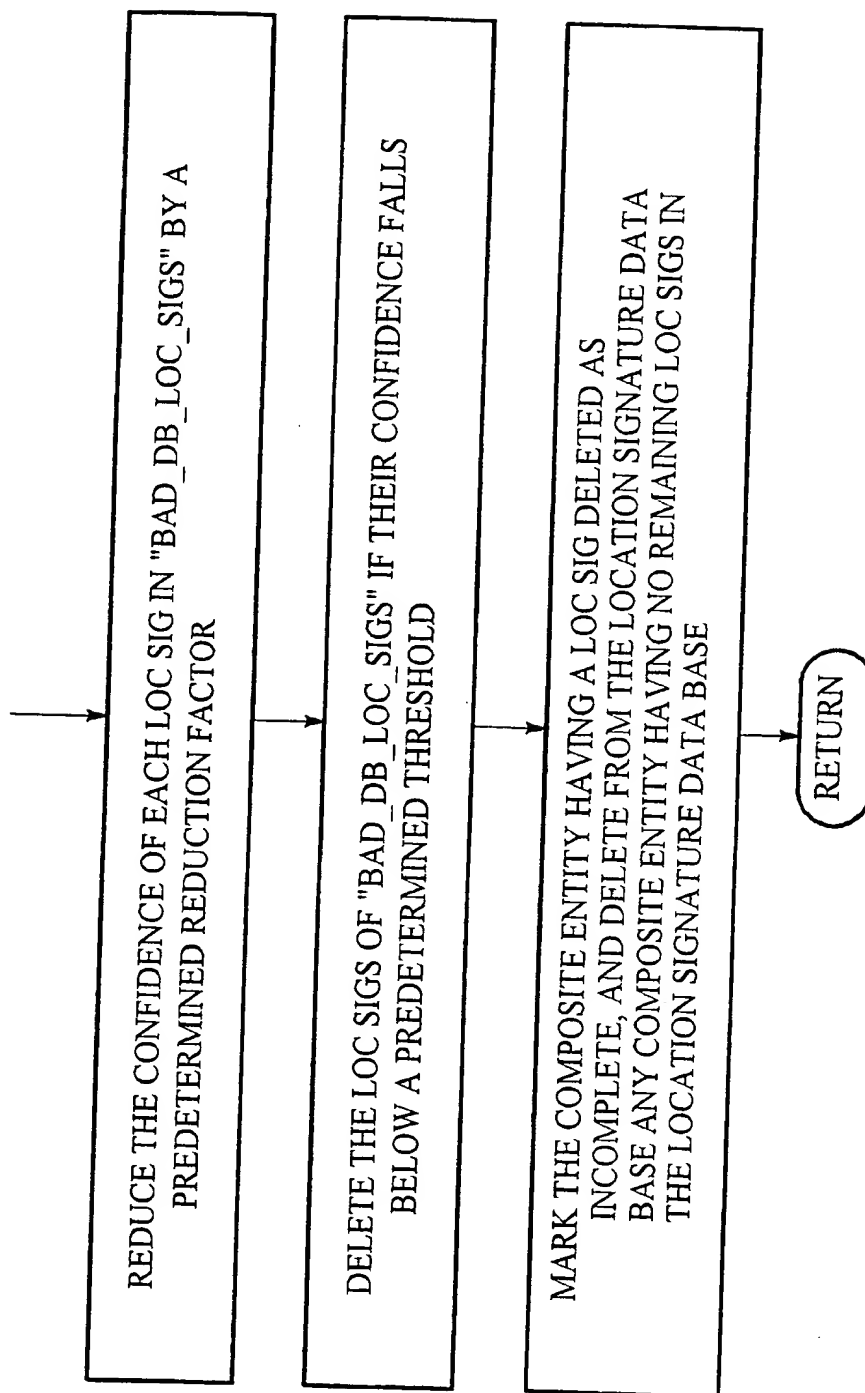


FIG. 18B

INCREASE\_CONFIDENCE\_OF\_GOOD\_DB\_LOC\_SIGS(LOC\_SIG\_BAG)

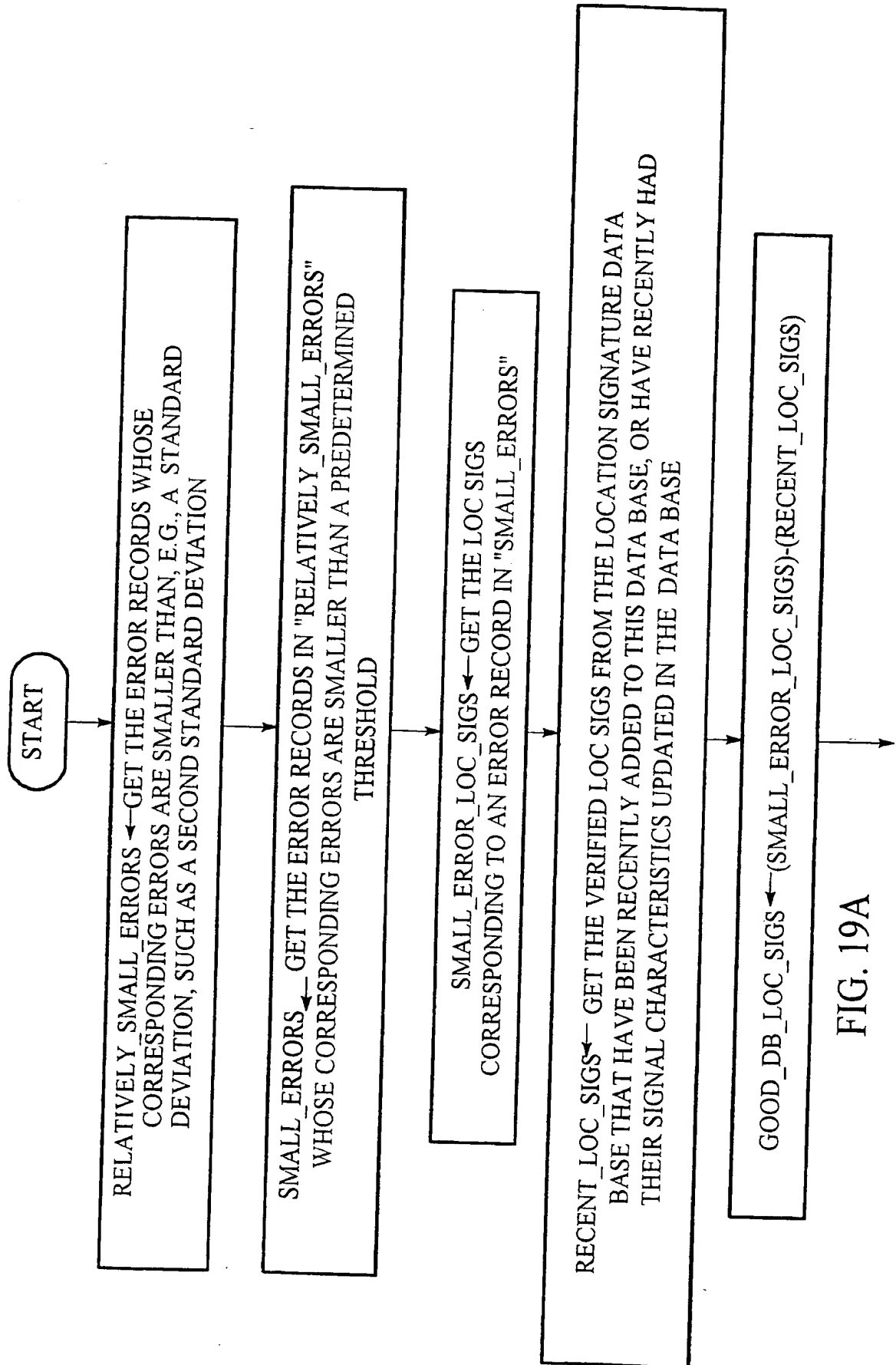


FIG. 19A



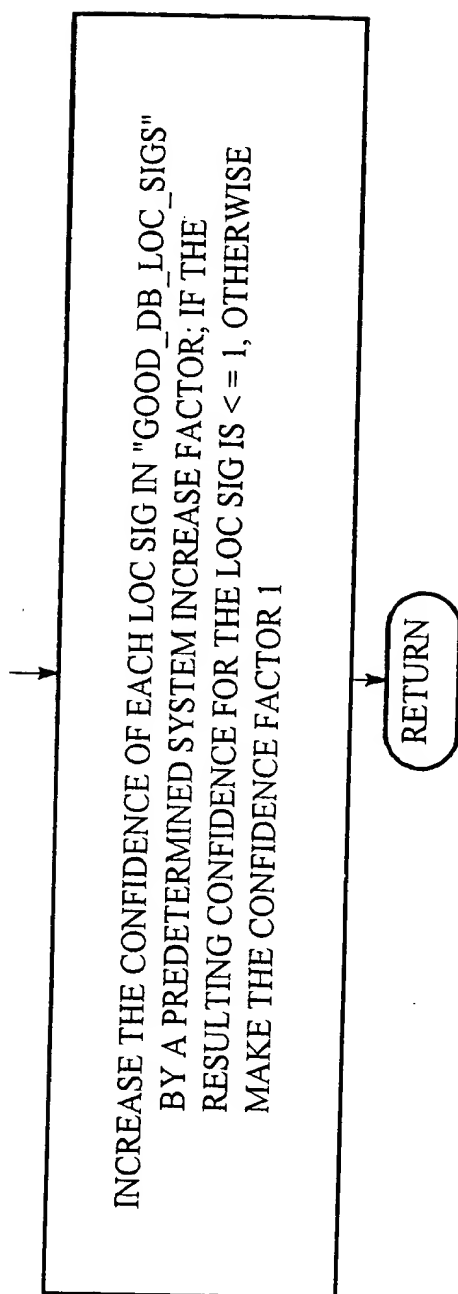
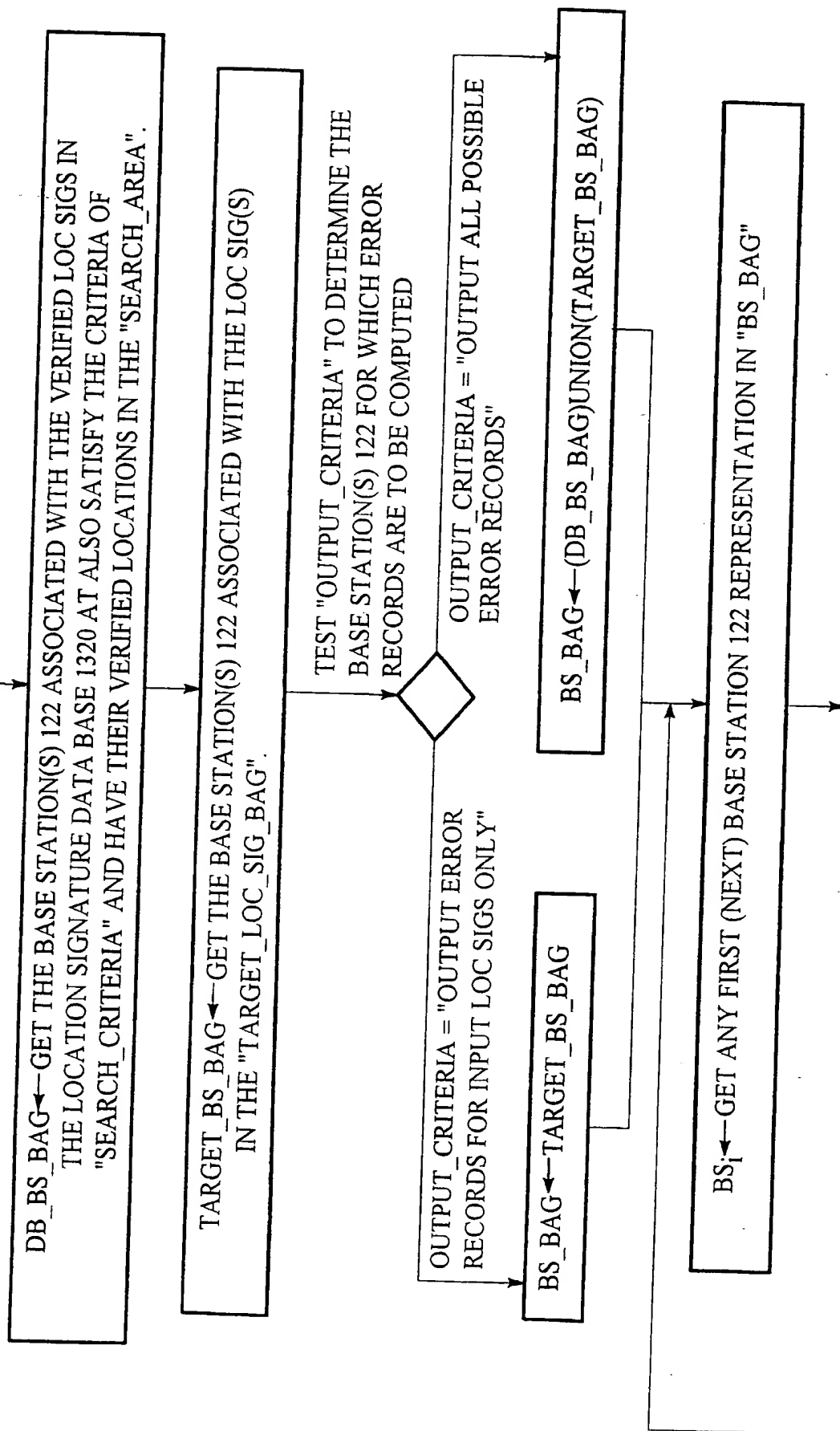


FIG. 19B

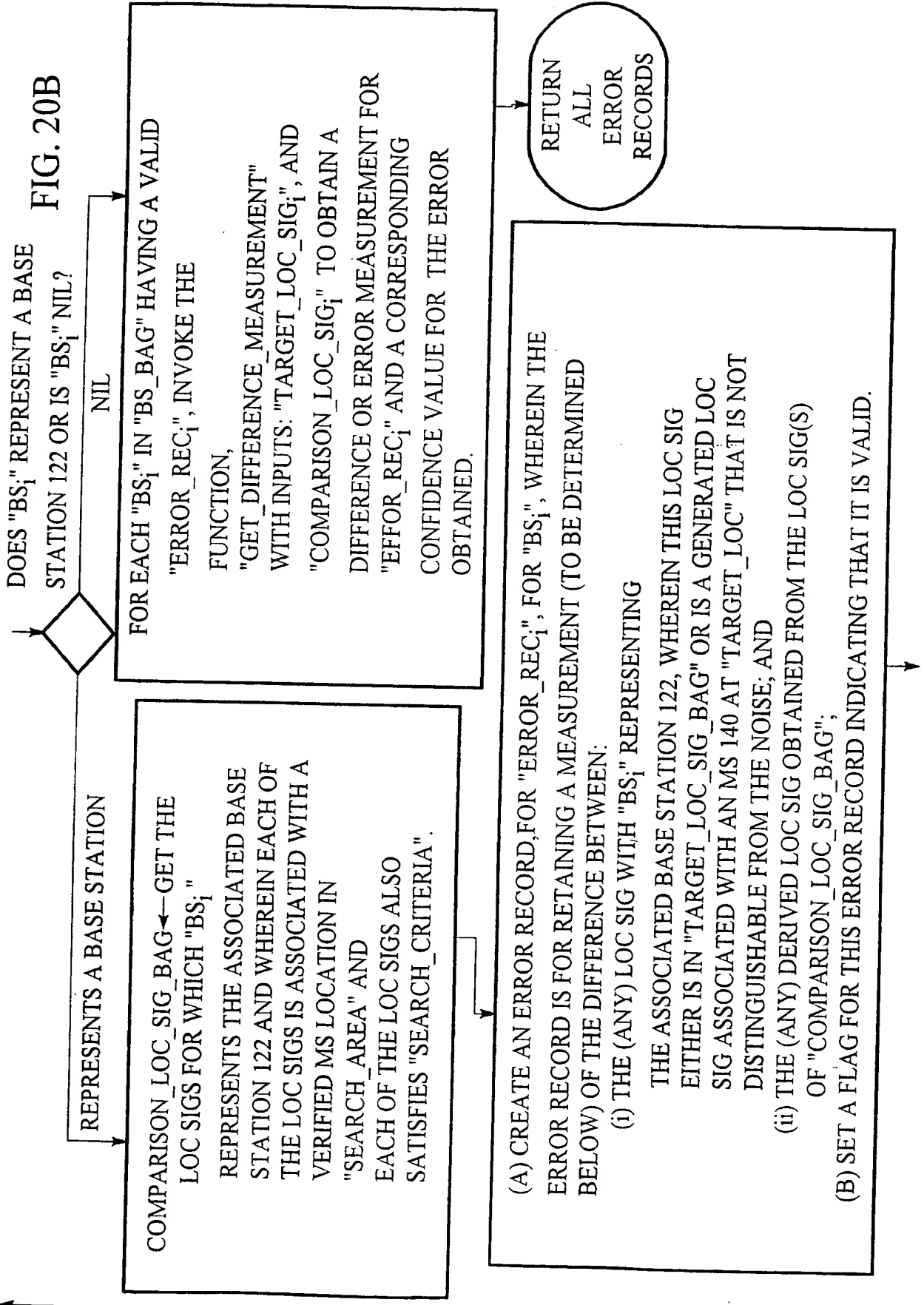
DETERMINE\_LOCATION\_SIGNATURE\_FIT\_ERRORS  
(TARGET\_LOC, TARGET\_LOC\_SIG\_BAG, SEARCH\_AREA, SEARCH\_CRITERIA,  
OUTPUT\_CRITERIA)

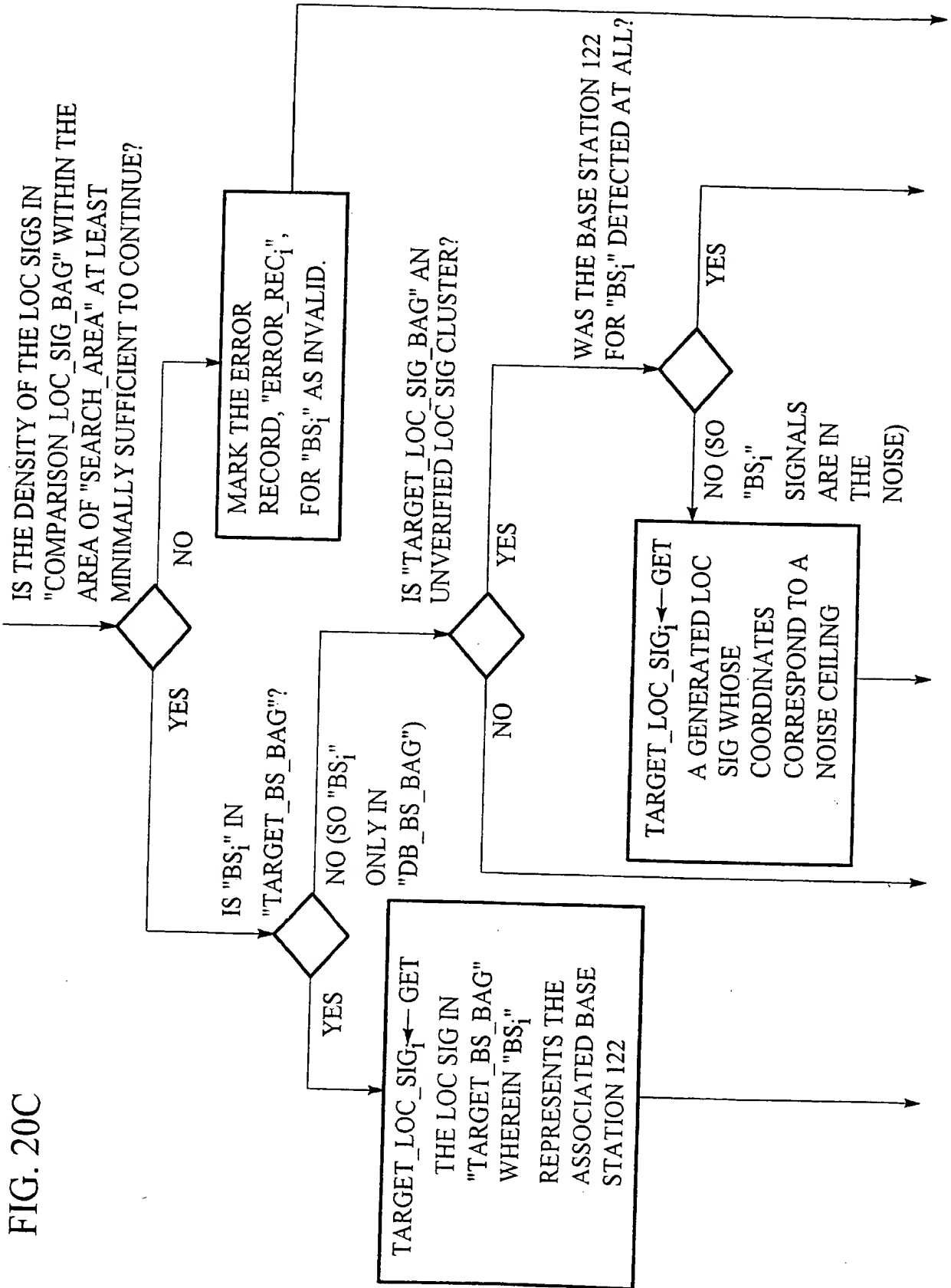
FIG. 20A



27/54

FIG. 20B





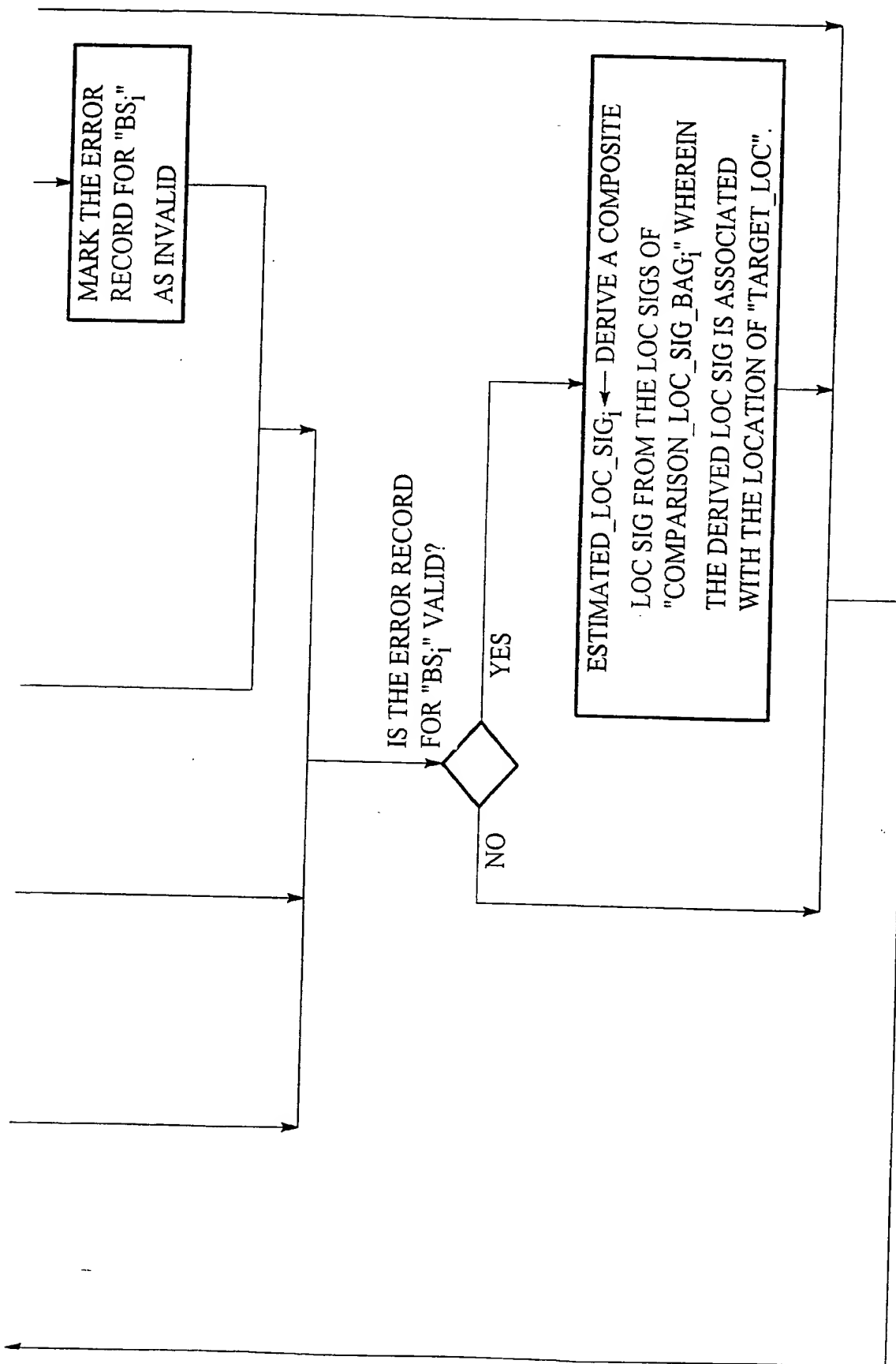
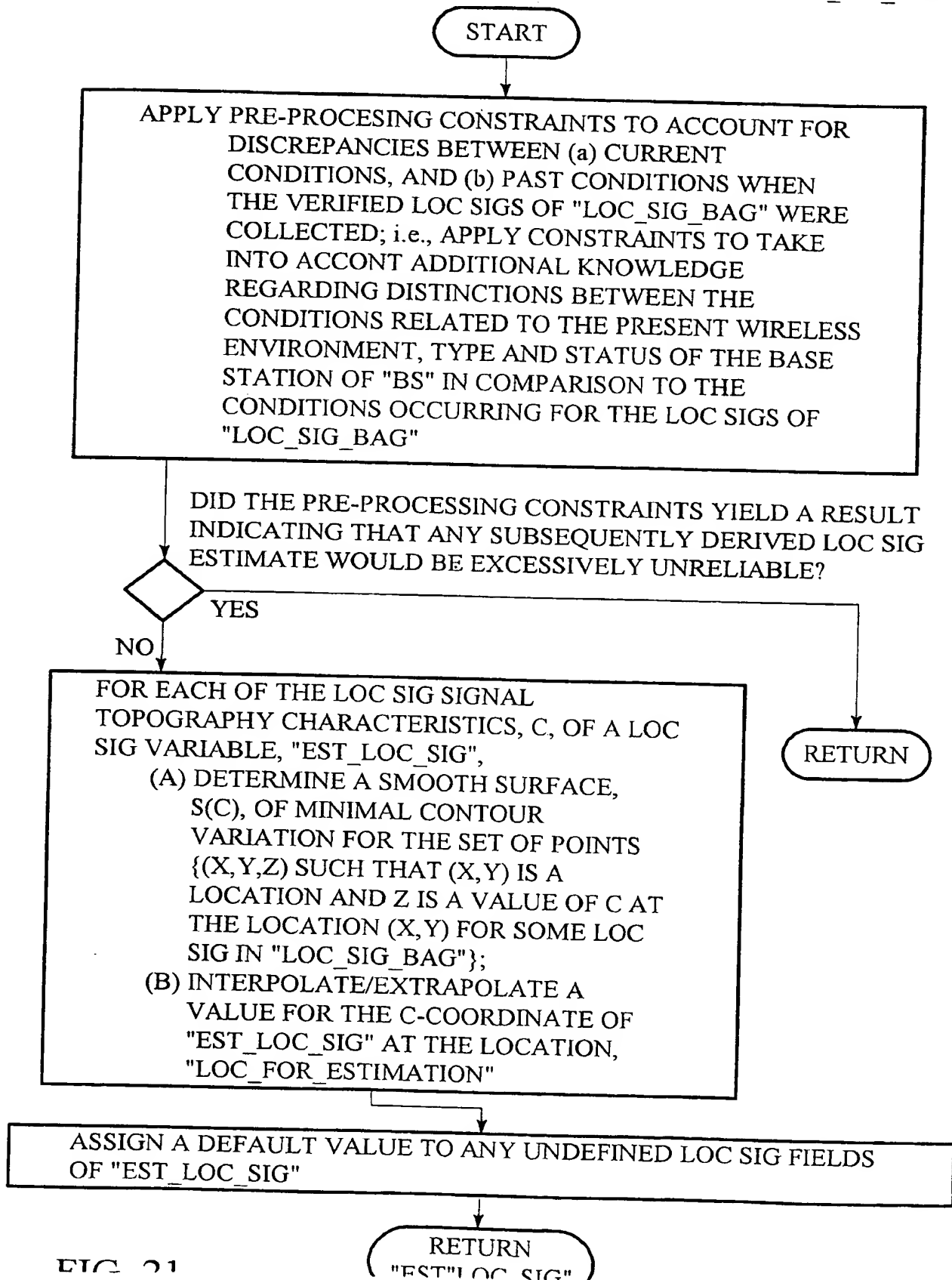


FIG. 20D

ESTIMATE\_LOC\_SIG\_FROM\_DB(LOC\_FOR\_ESTIMATION, BS, BS\_SIG\_BAG)



31/54

GET\_AREA\_TO\_SEARCH (LOC)

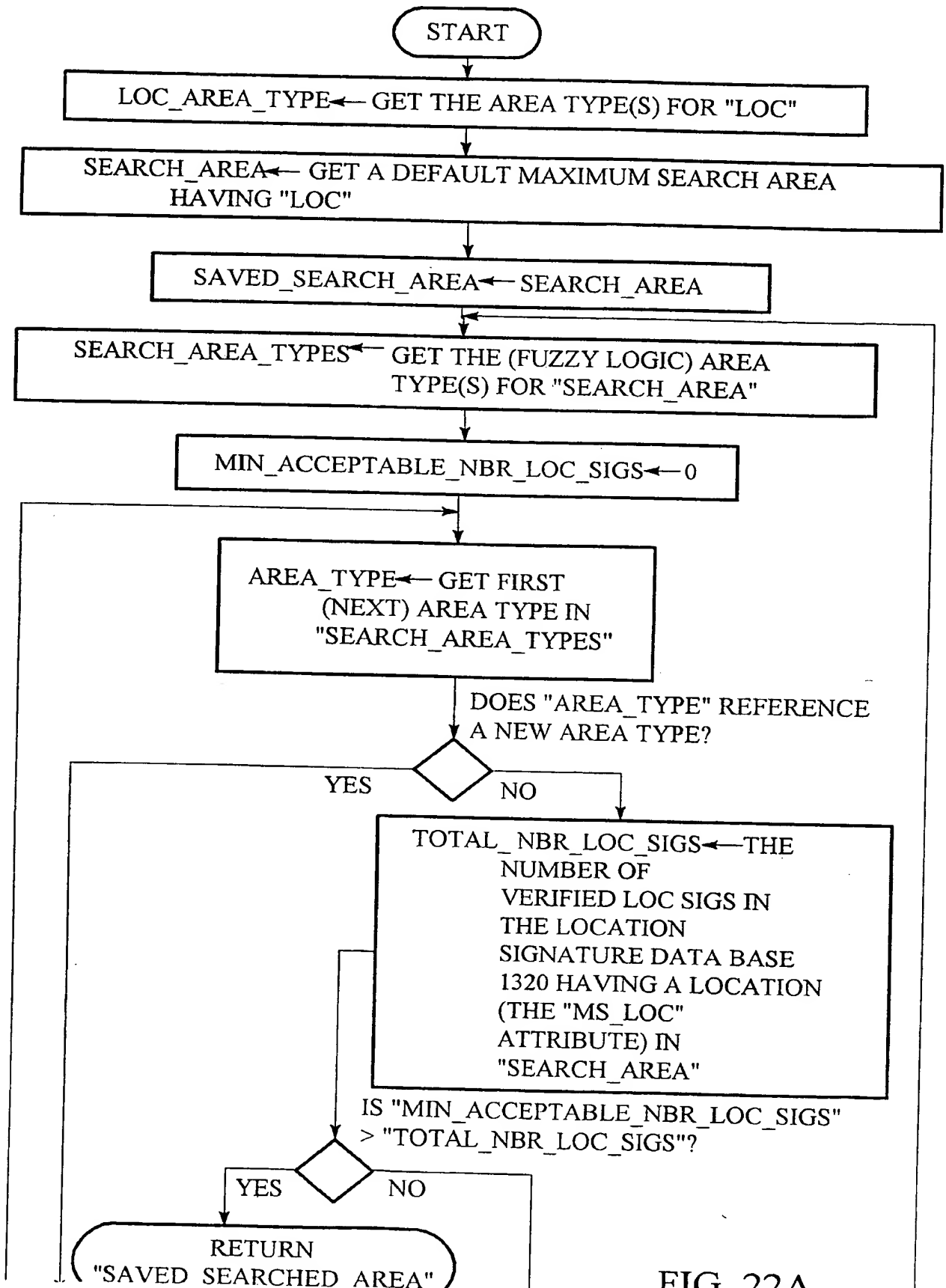


FIG. 22A

32/54

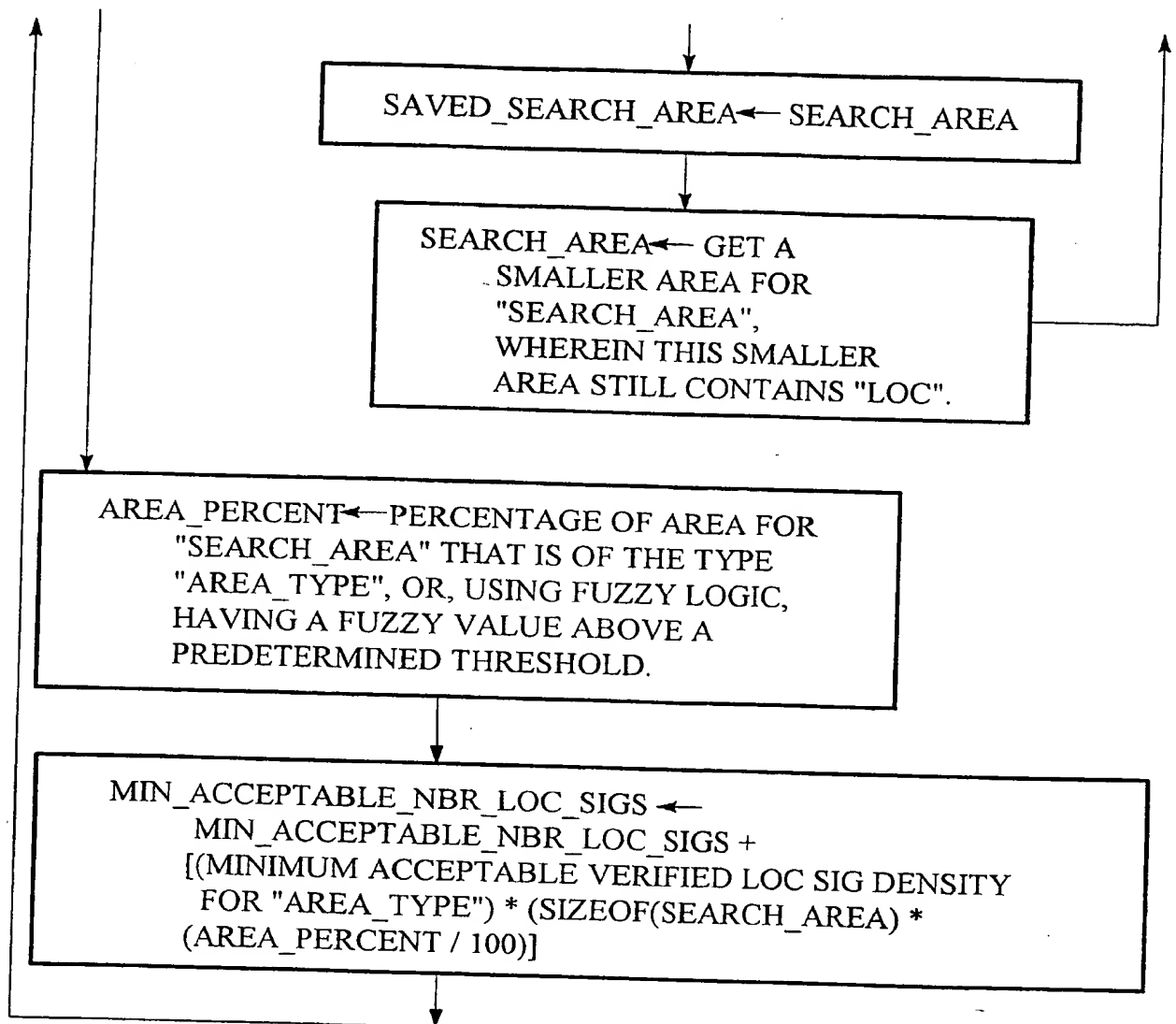
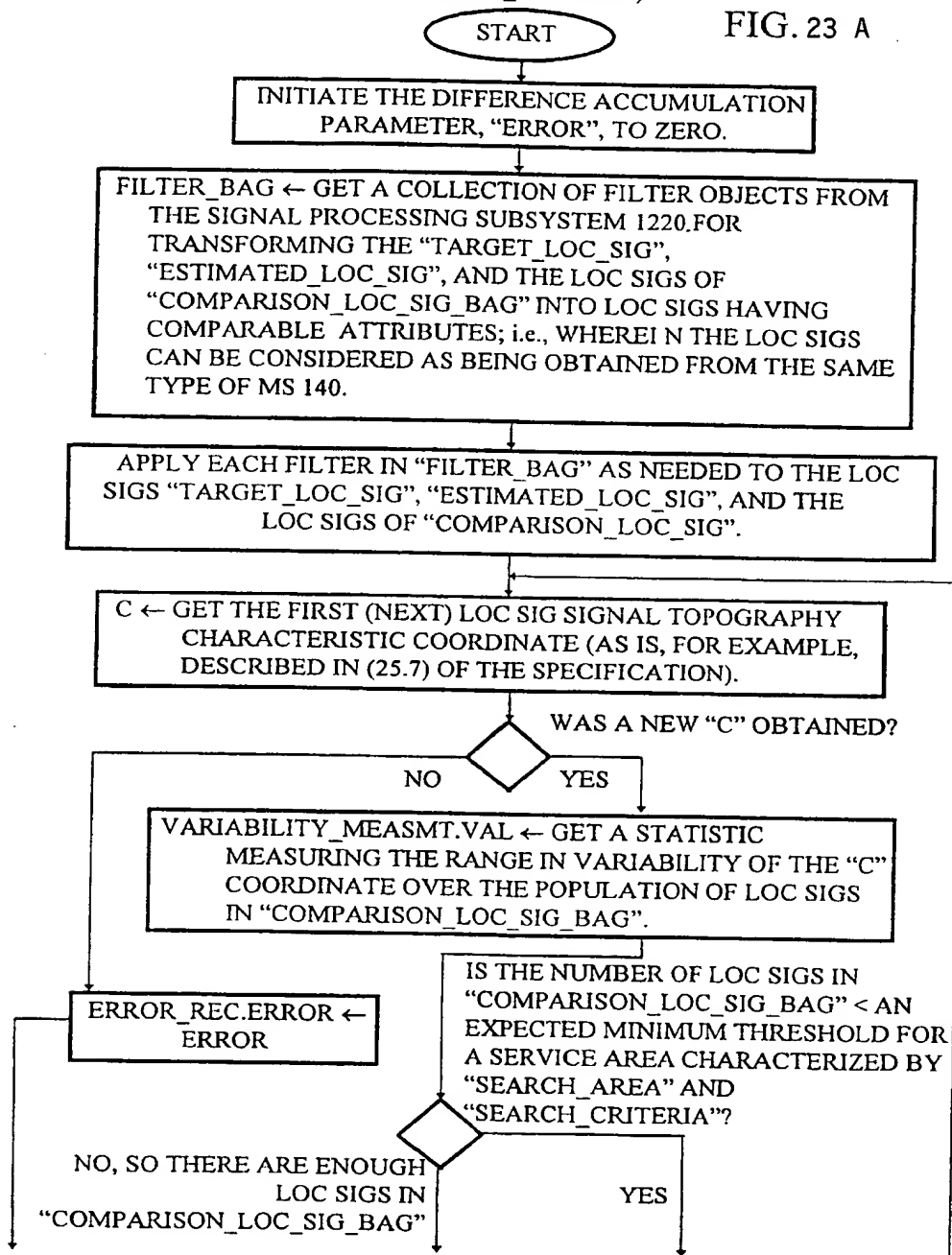


FIG. 22B



GET\_DIFFERENCE\_MEASUREMENT(TARGET\_LOC\_SIG,  
ESTIMATED\_LOC\_SIG, COMPARISON\_LOC\_SIG\_BAG, SEARCH\_AREA,  
SEARCH\_CRITERIA)

FIG. 23 A



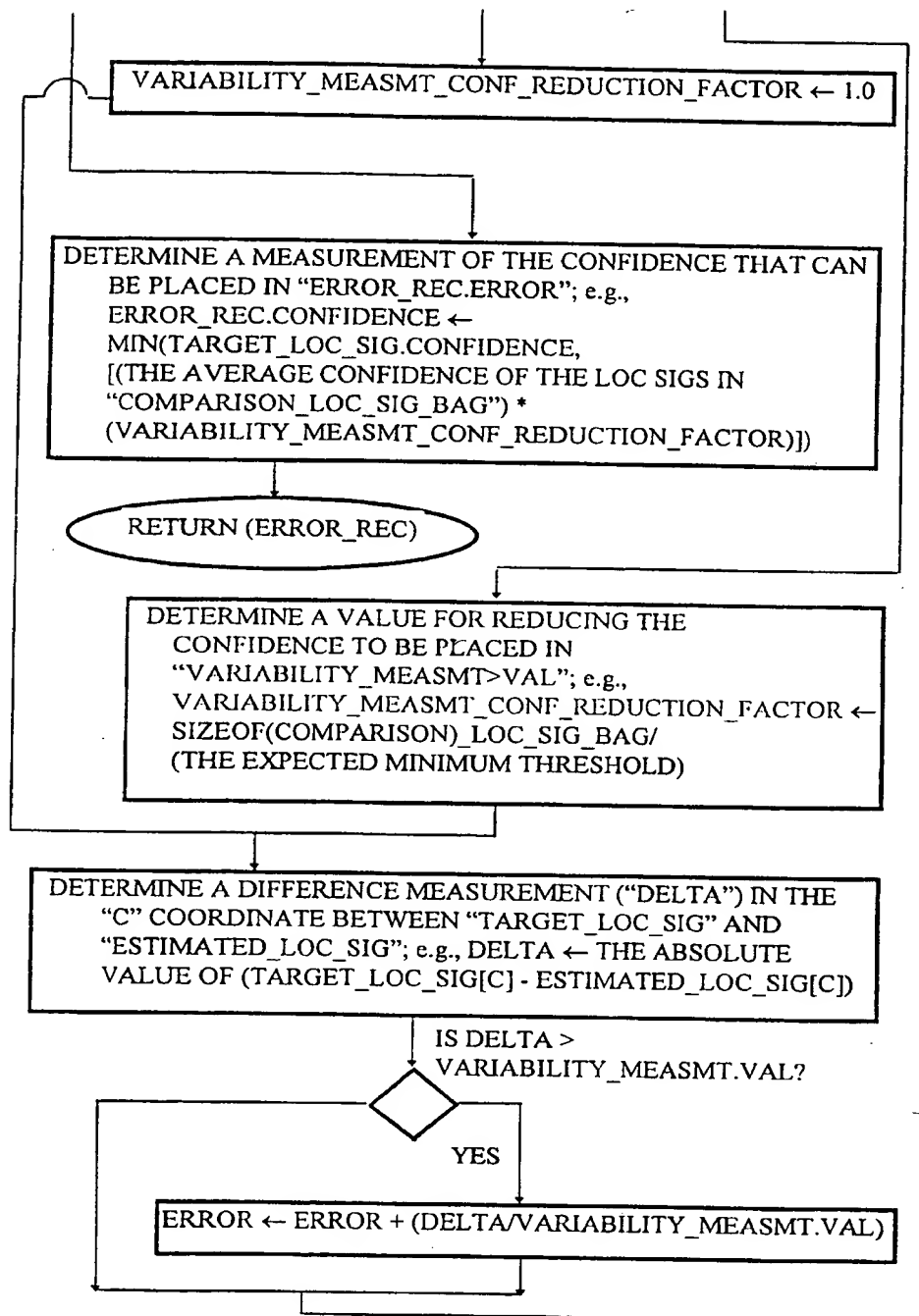
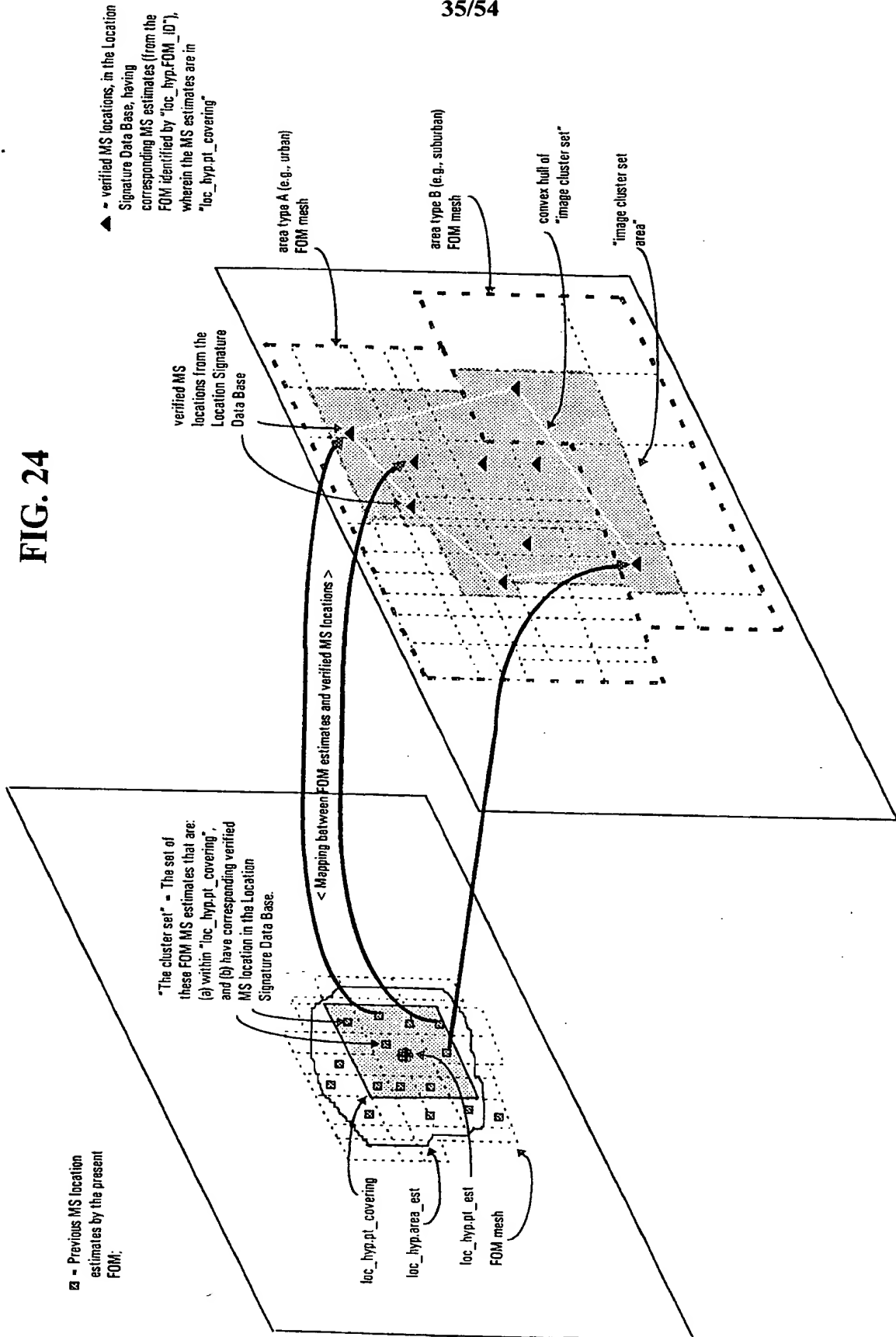


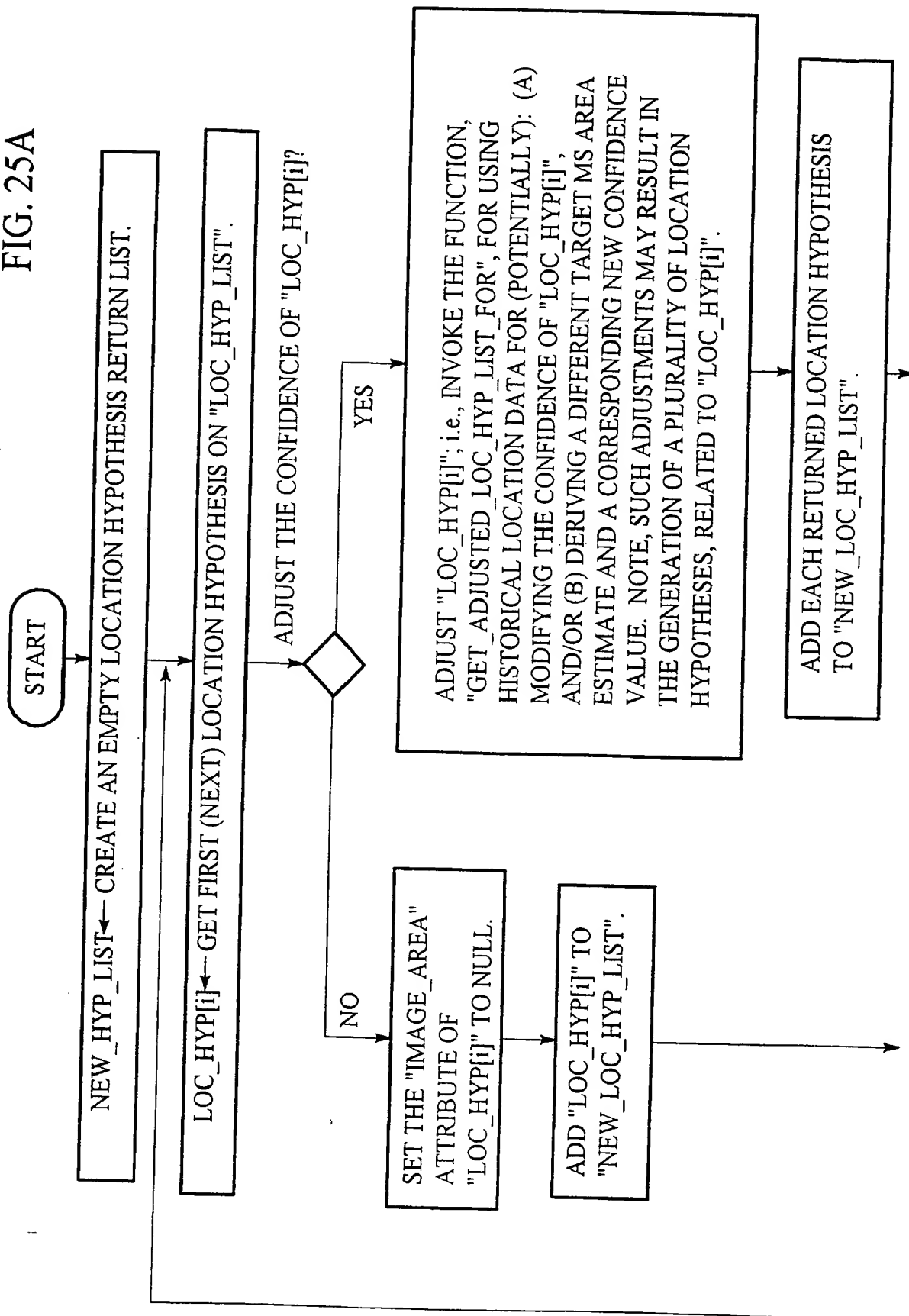
FIG. 23B

FIG. 24



CONTEXT\_ADJUSTER(LOC\_HYP\_LIST)

FIG. 25A



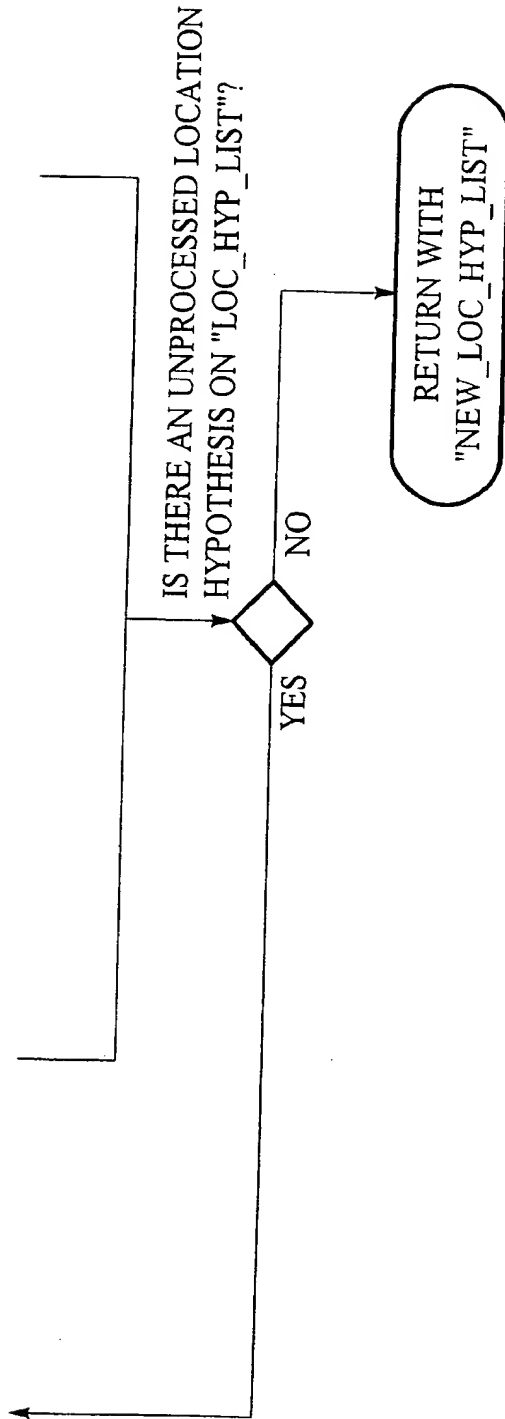
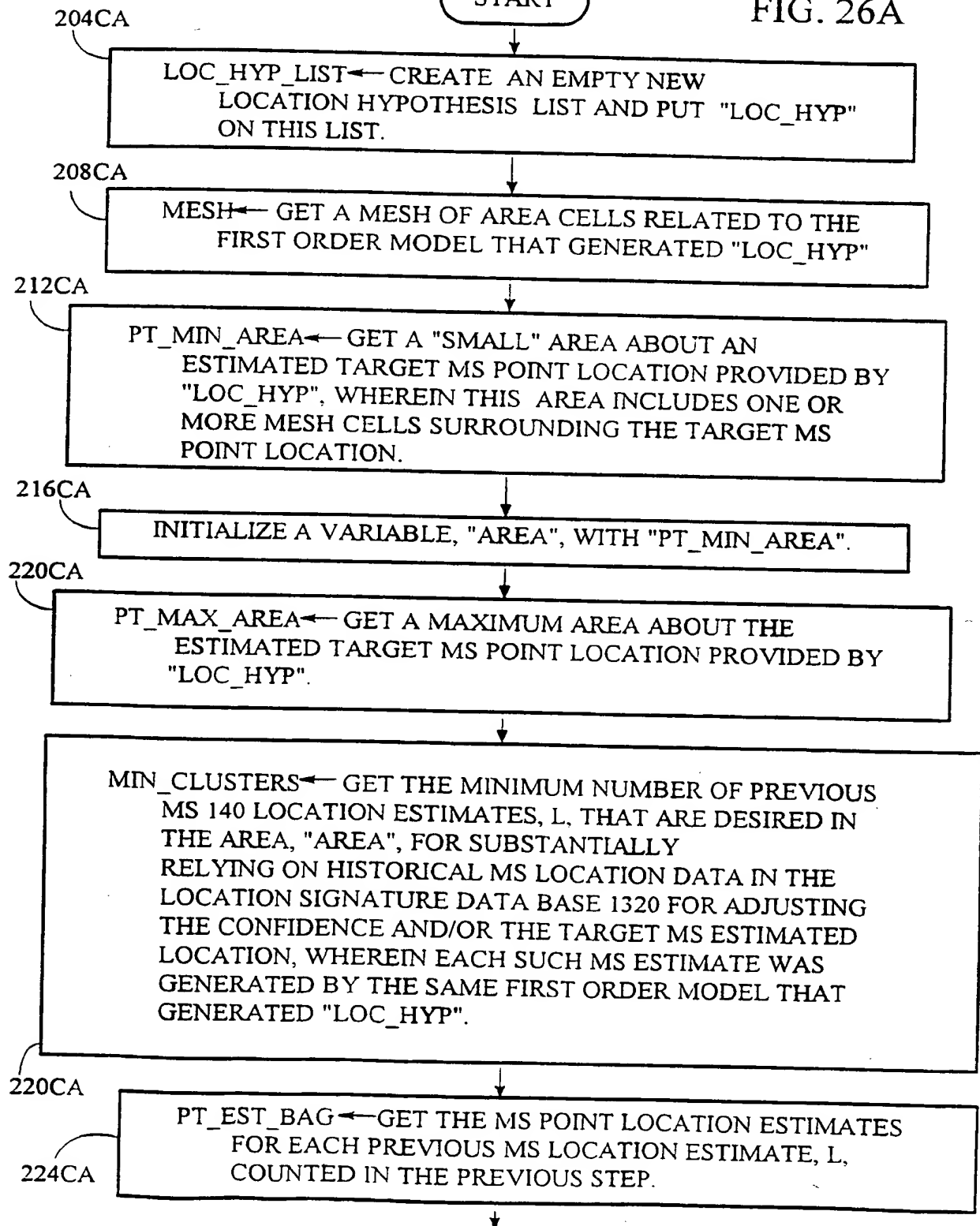


FIG. 25B

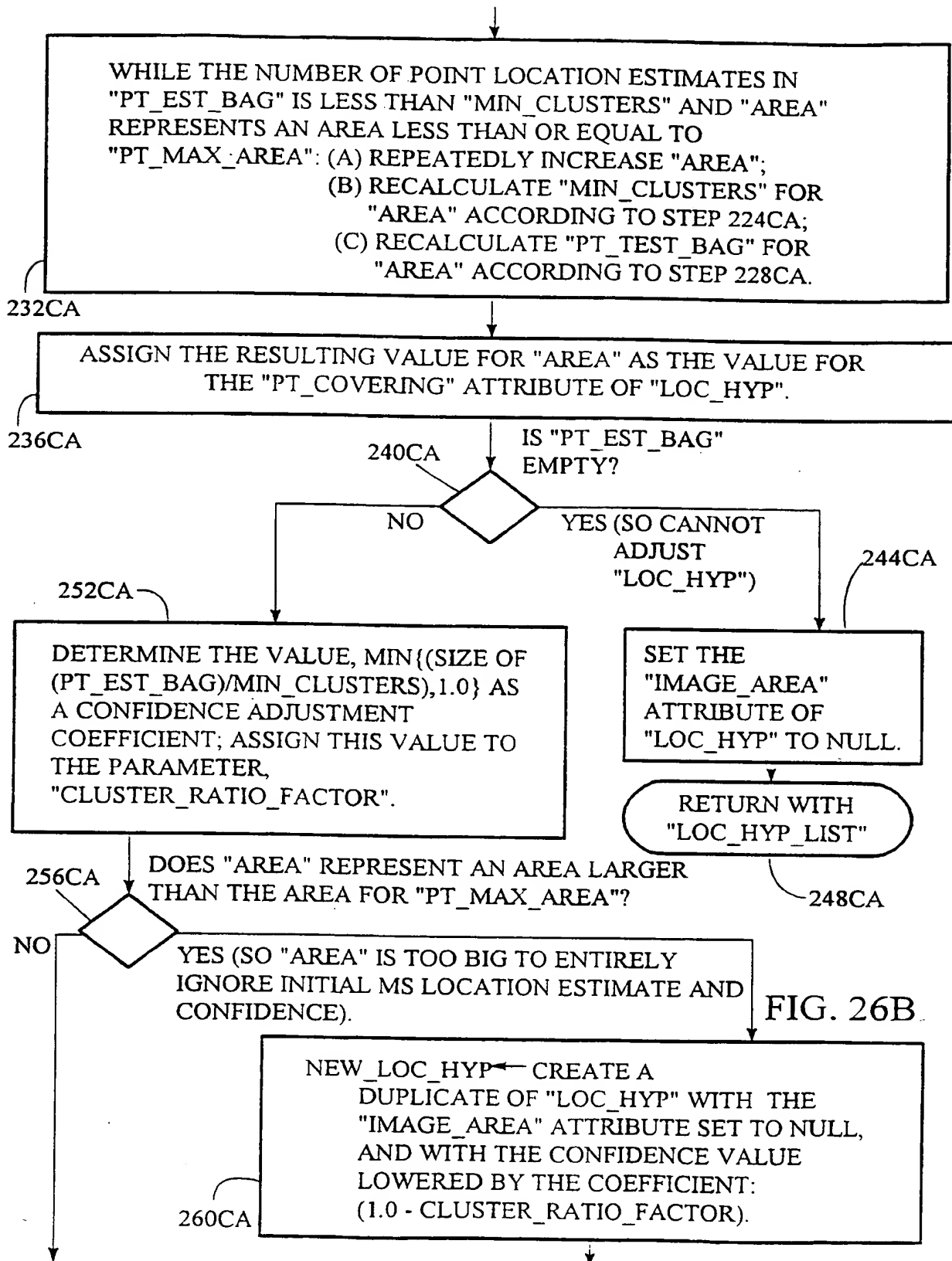
GET\_ADJUSTED\_LOC\_HYP\_LIST\_FOR(LOC\_HYP)

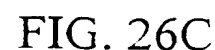
START

FIG. 26A



39/54







CONFIDENCE\_ADJUSTER(FOM\_ID,IMAGE\_AREA,IMAGE\_CLUSTER\_SET)

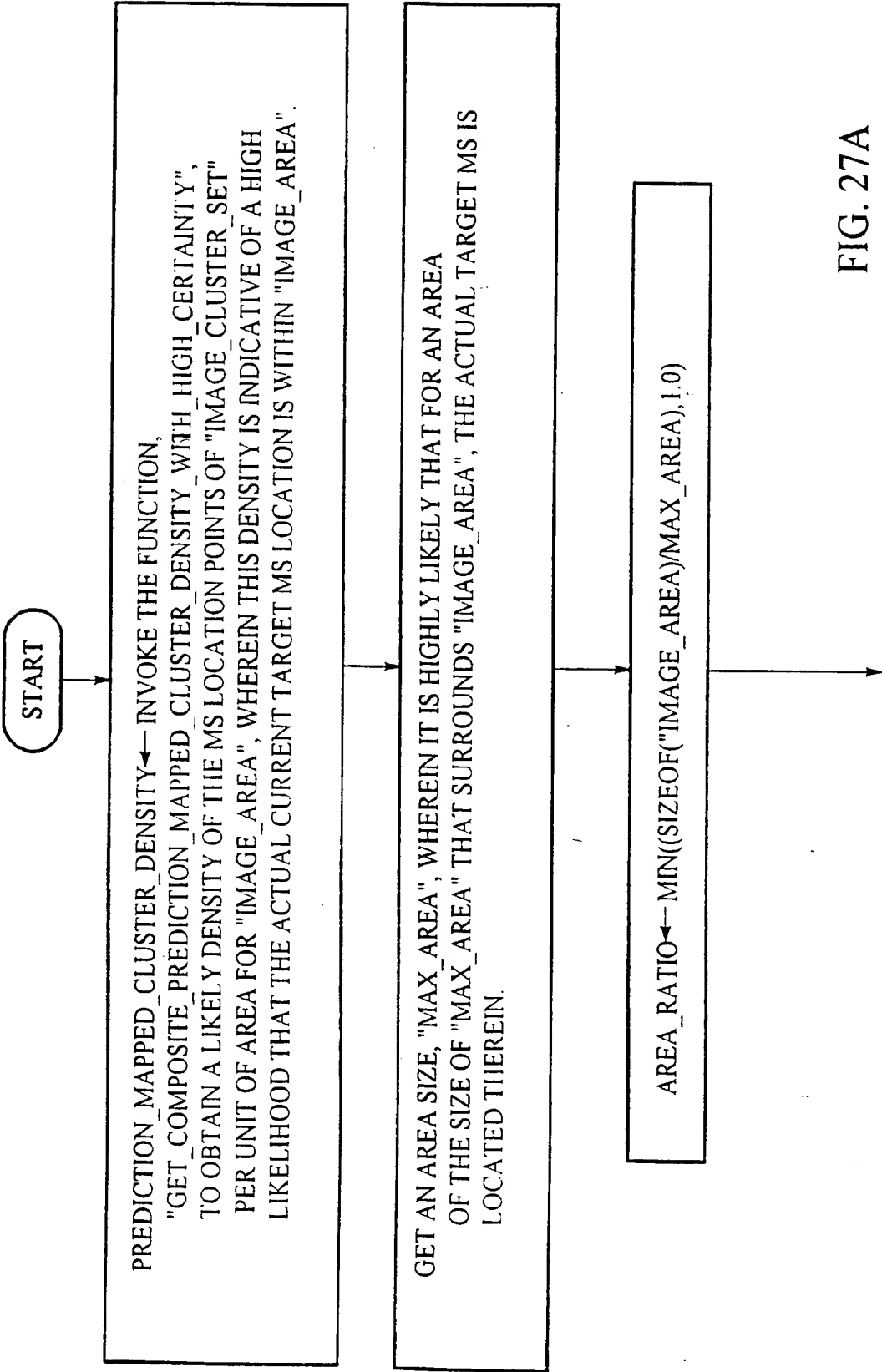


FIG. 27A

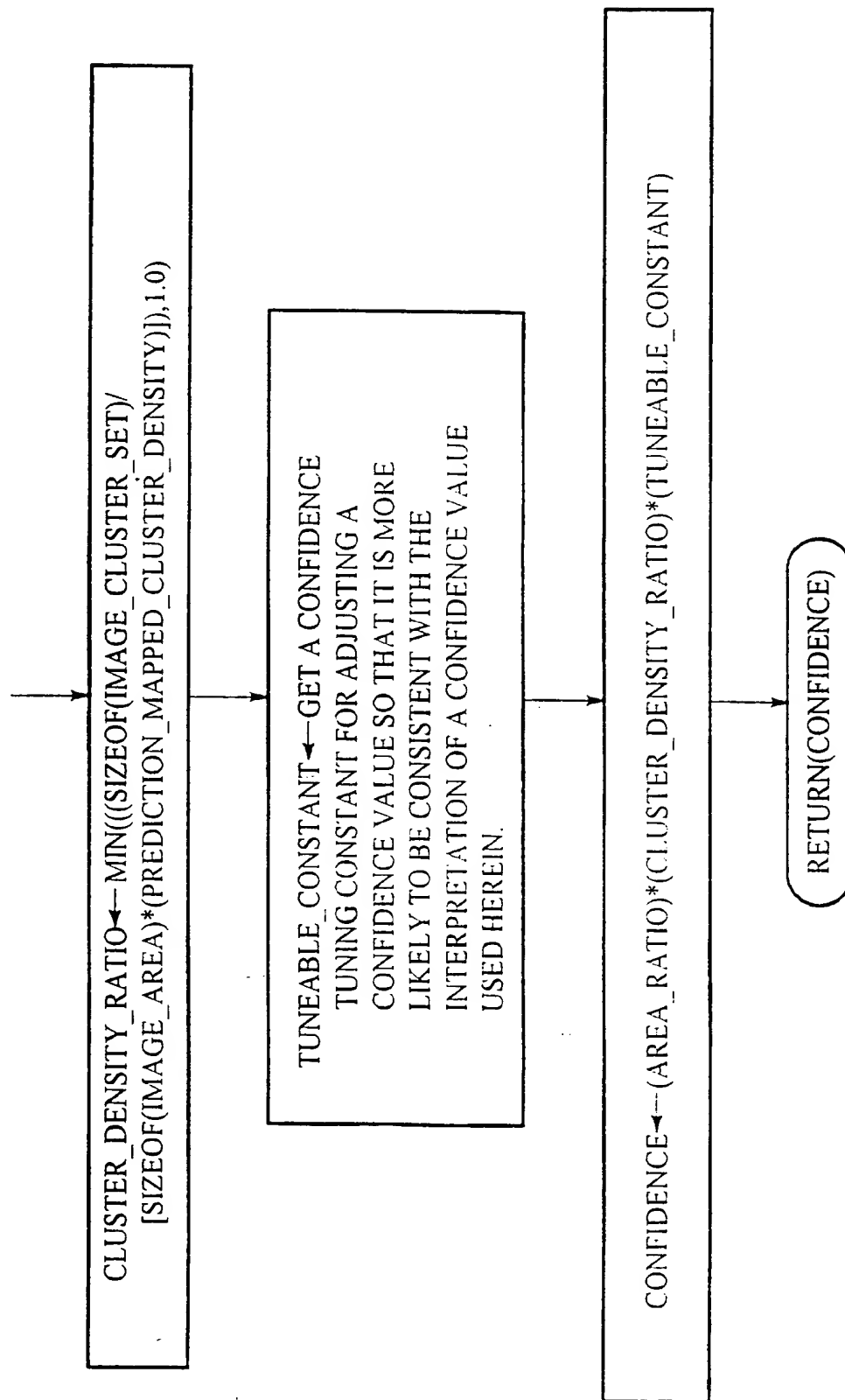
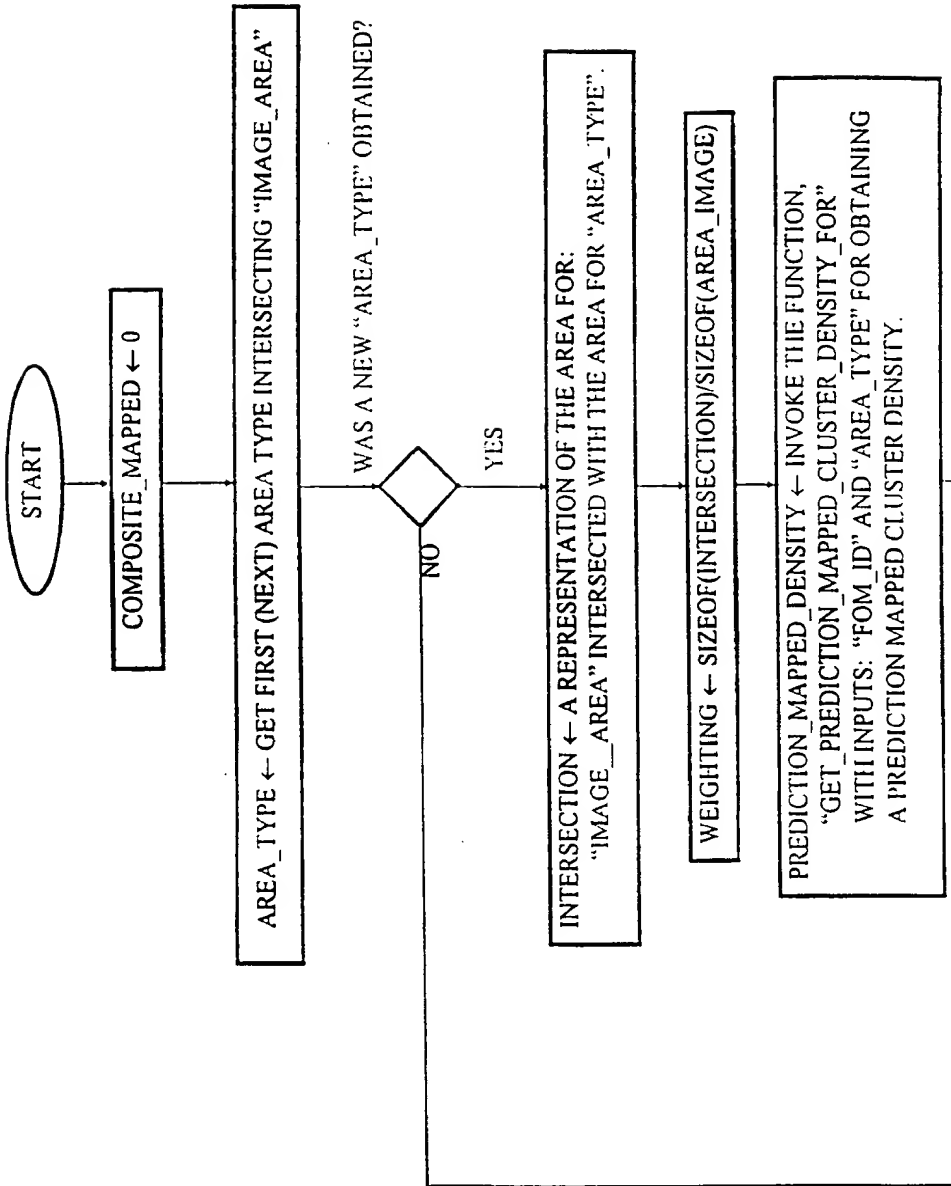


FIG. 27B

Fig. 28 A

GET\_COMPOSITE\_PREDICTION\_MAPPED\_CLUSTER\_DENSITY\_WITH\_HIGH\_CERTAINTY  
(FOM\_ID, IMAGE\_AREA)



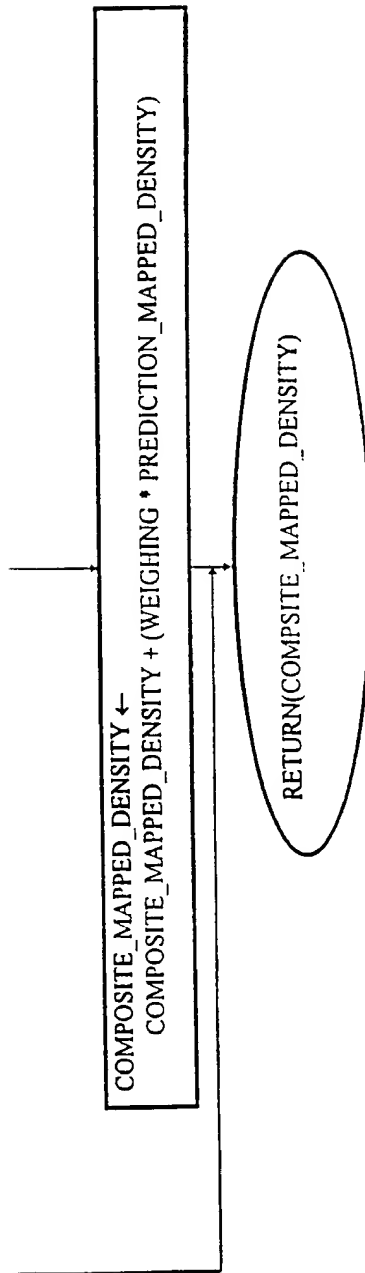


Fig.28B

GET\_PREDICTION\_MAPPED\_CLUSTER\_DENSITY\_FOR(FOM\_ID, AREA\_TYPE)

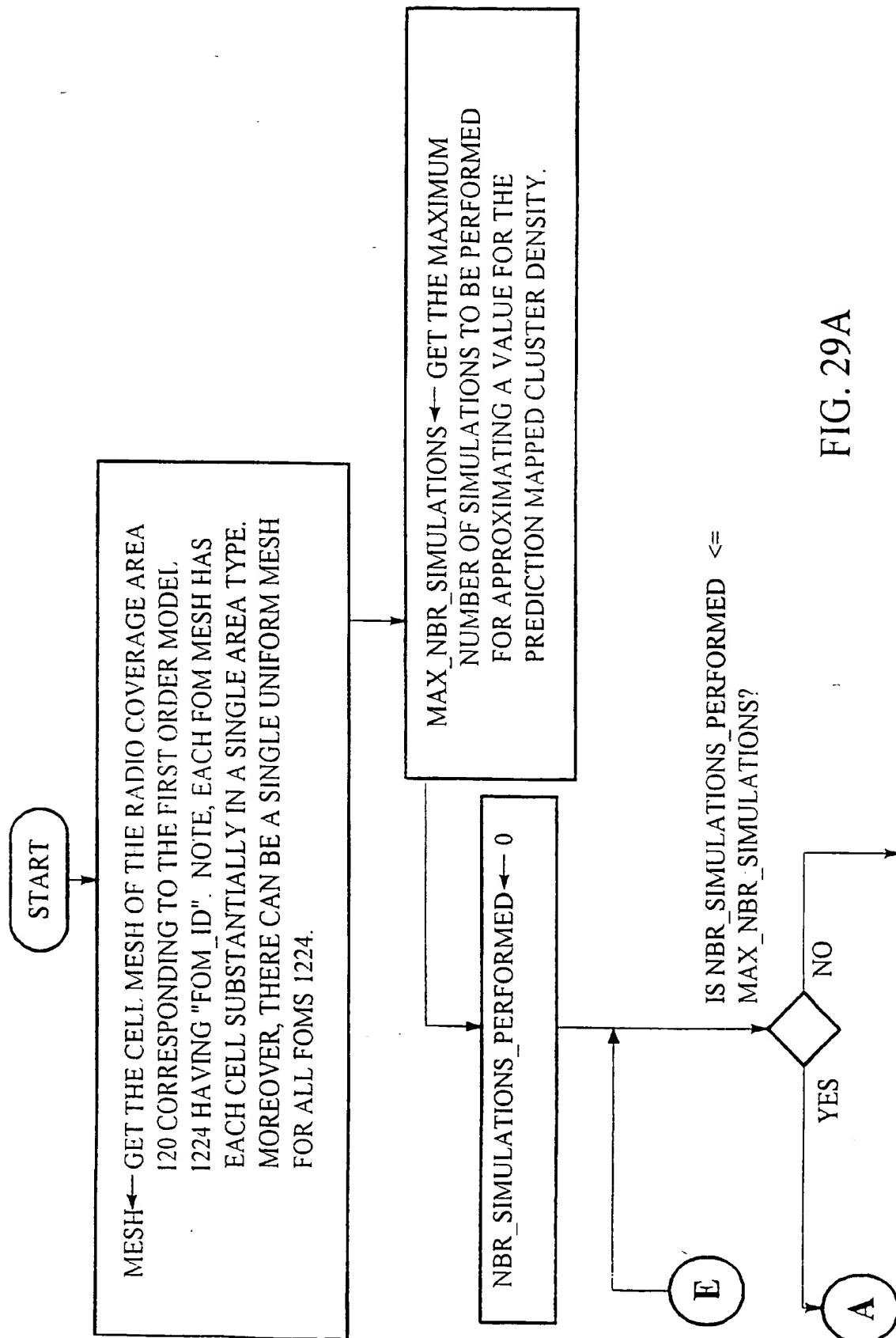
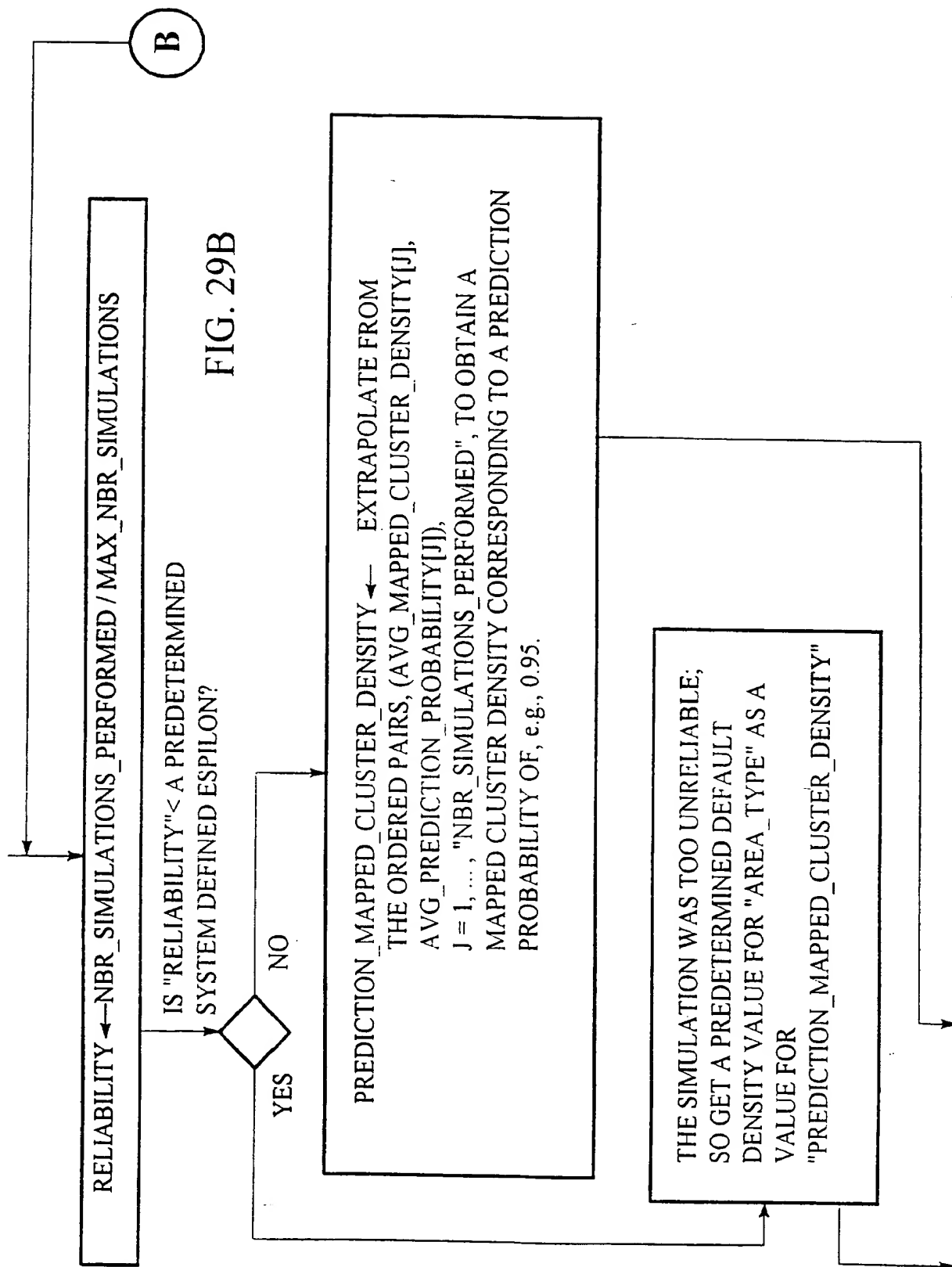


FIG. 29A



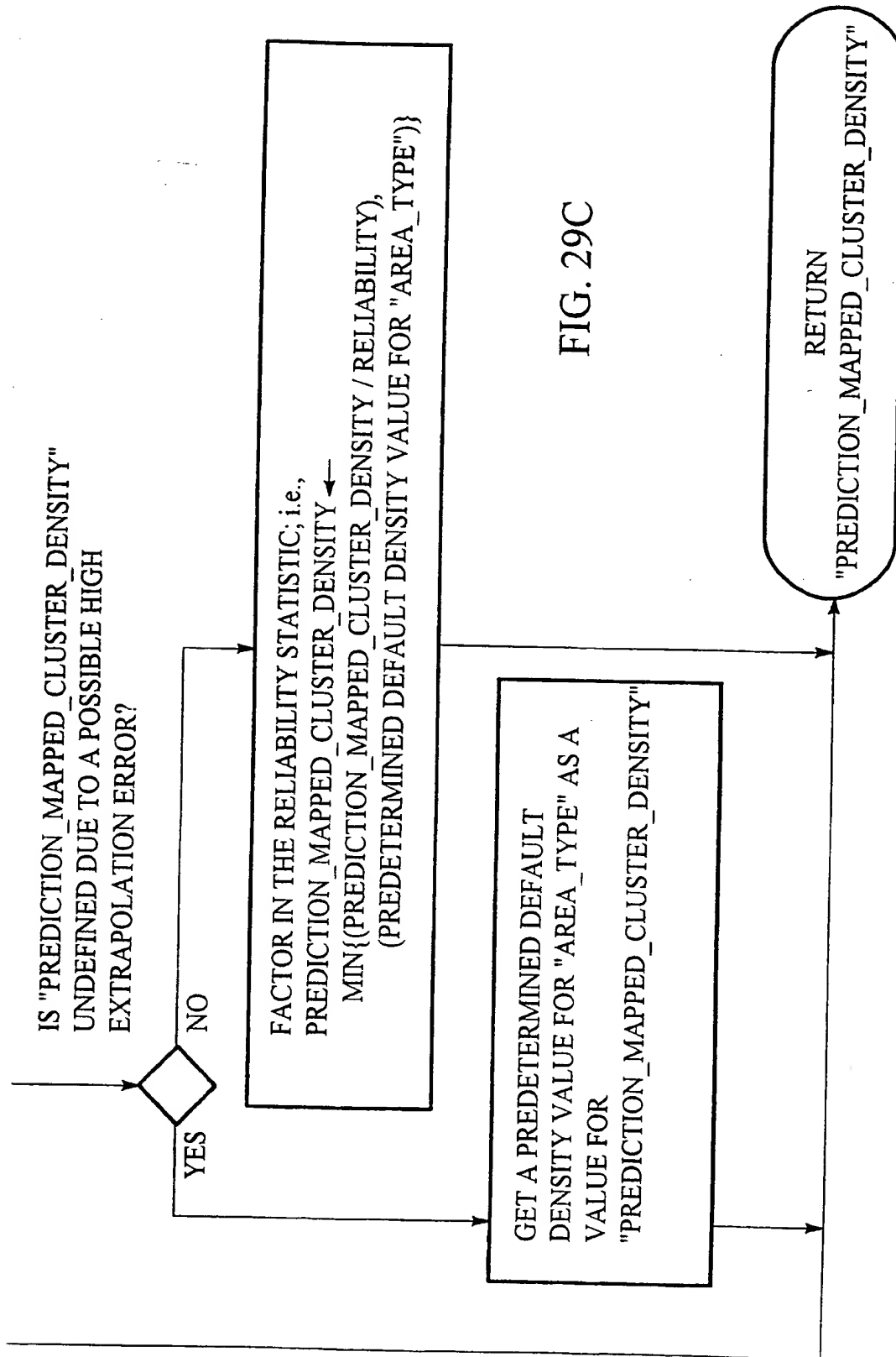


FIG. 29C

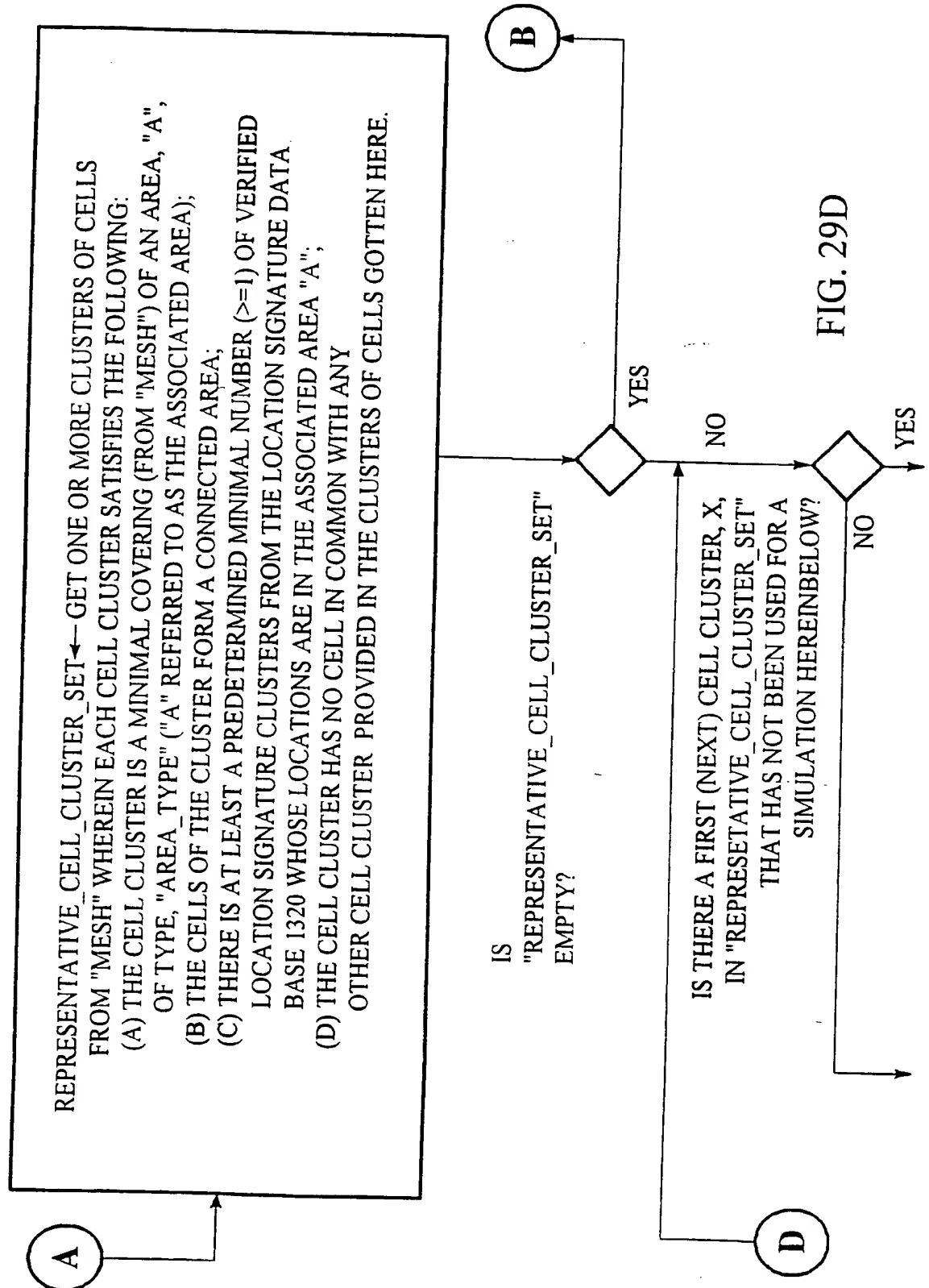
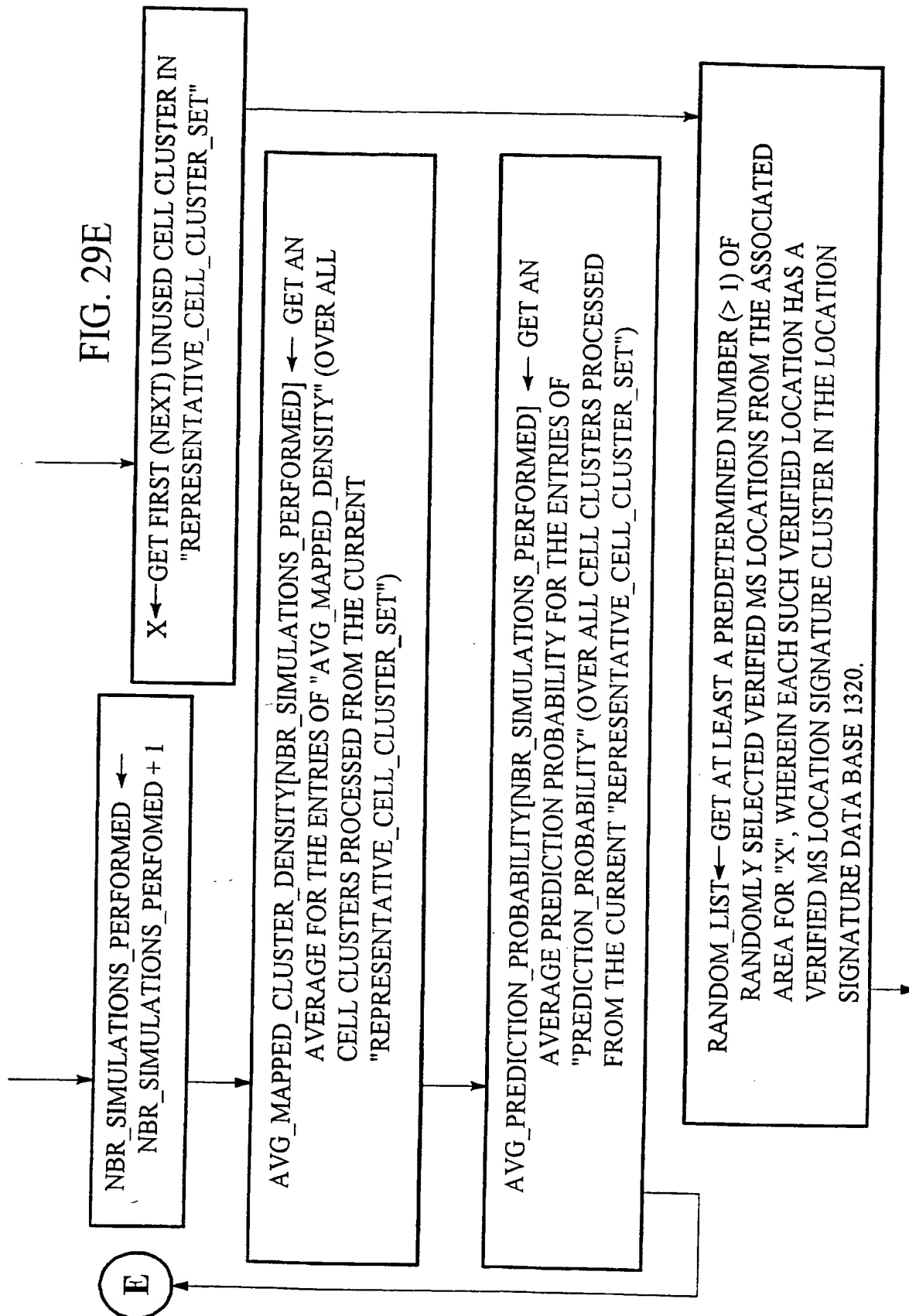
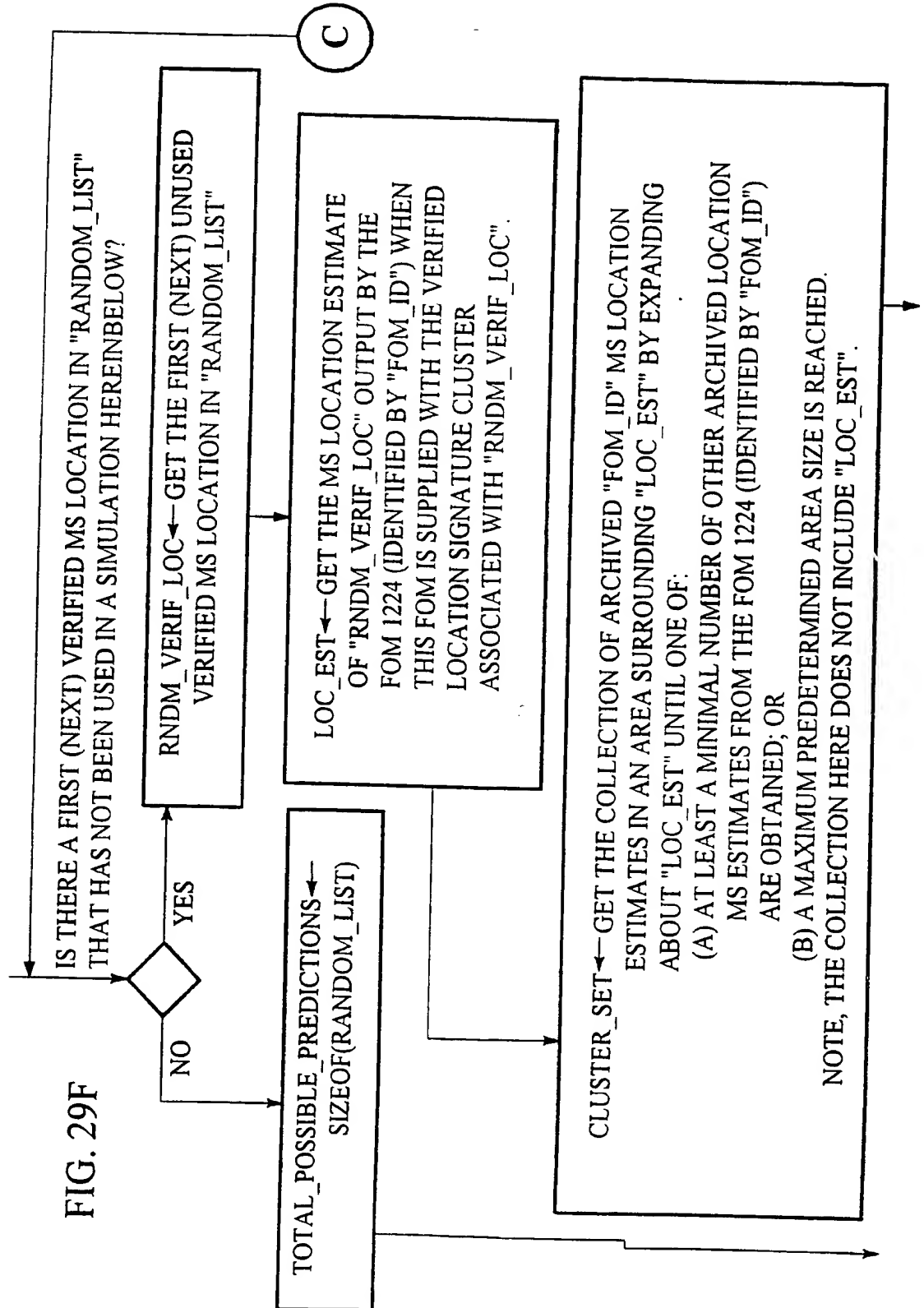




FIG. 29E





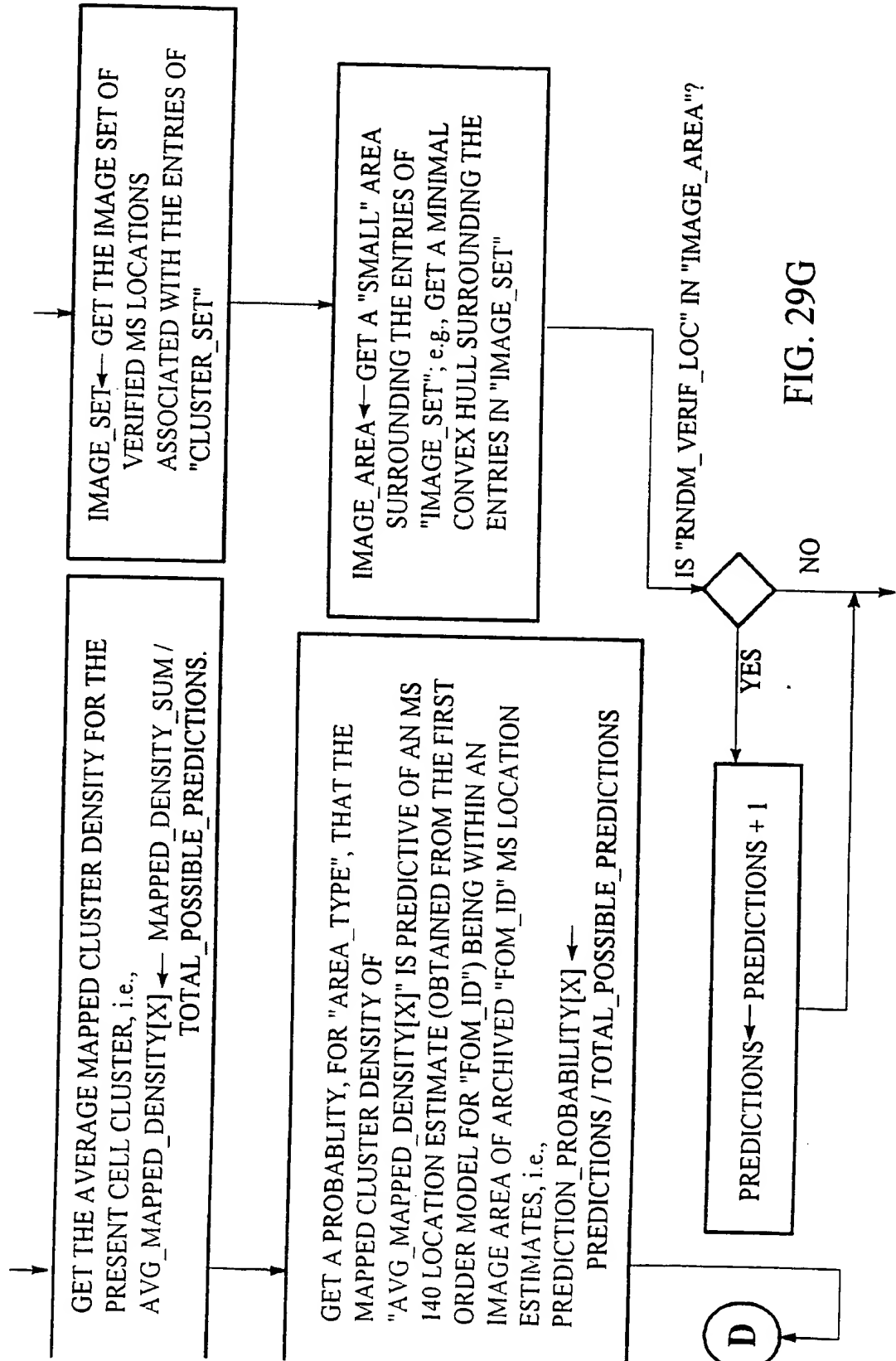
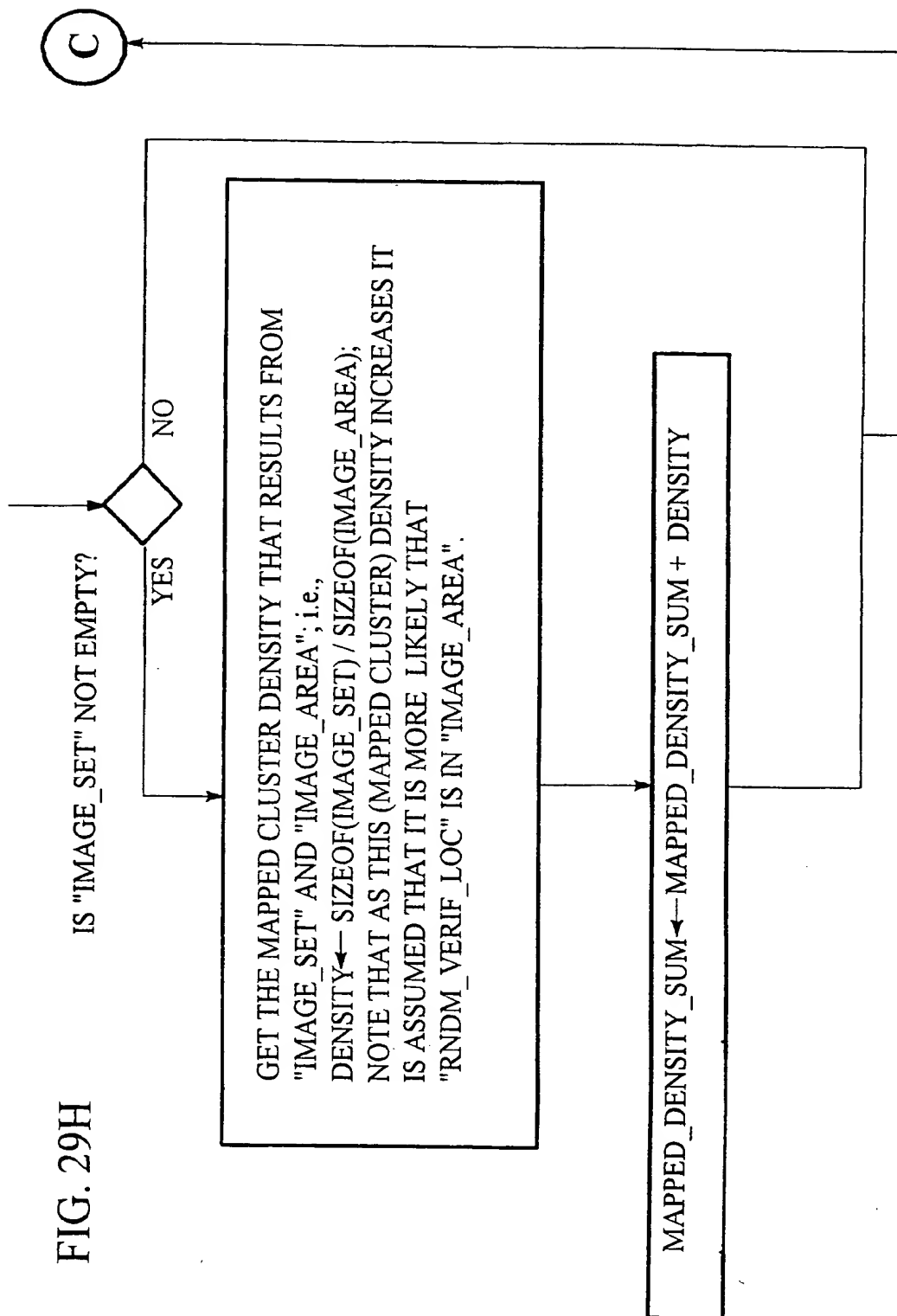


FIG. 29G



53/54

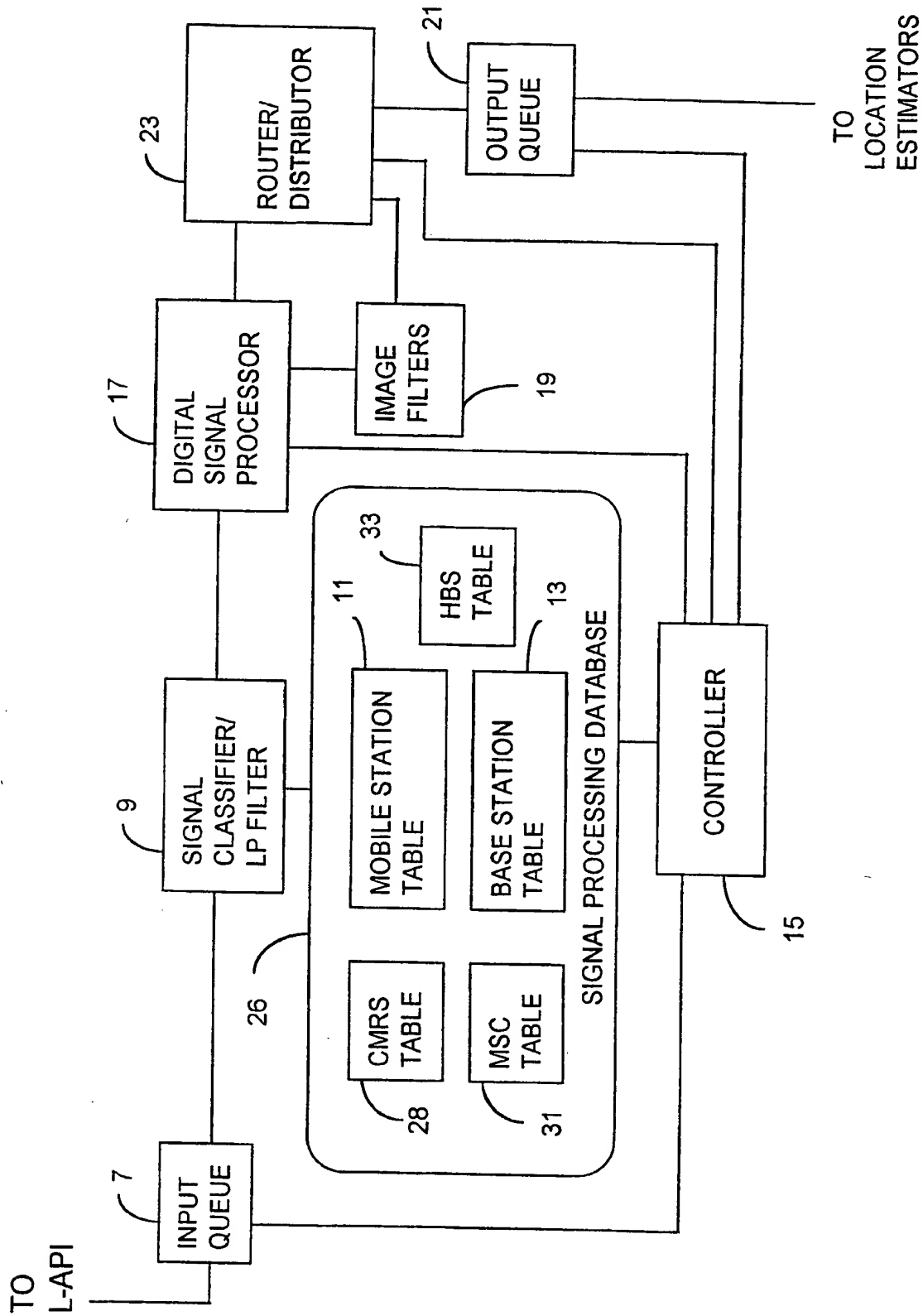


Fig. 30: Signal Processing Subsystem

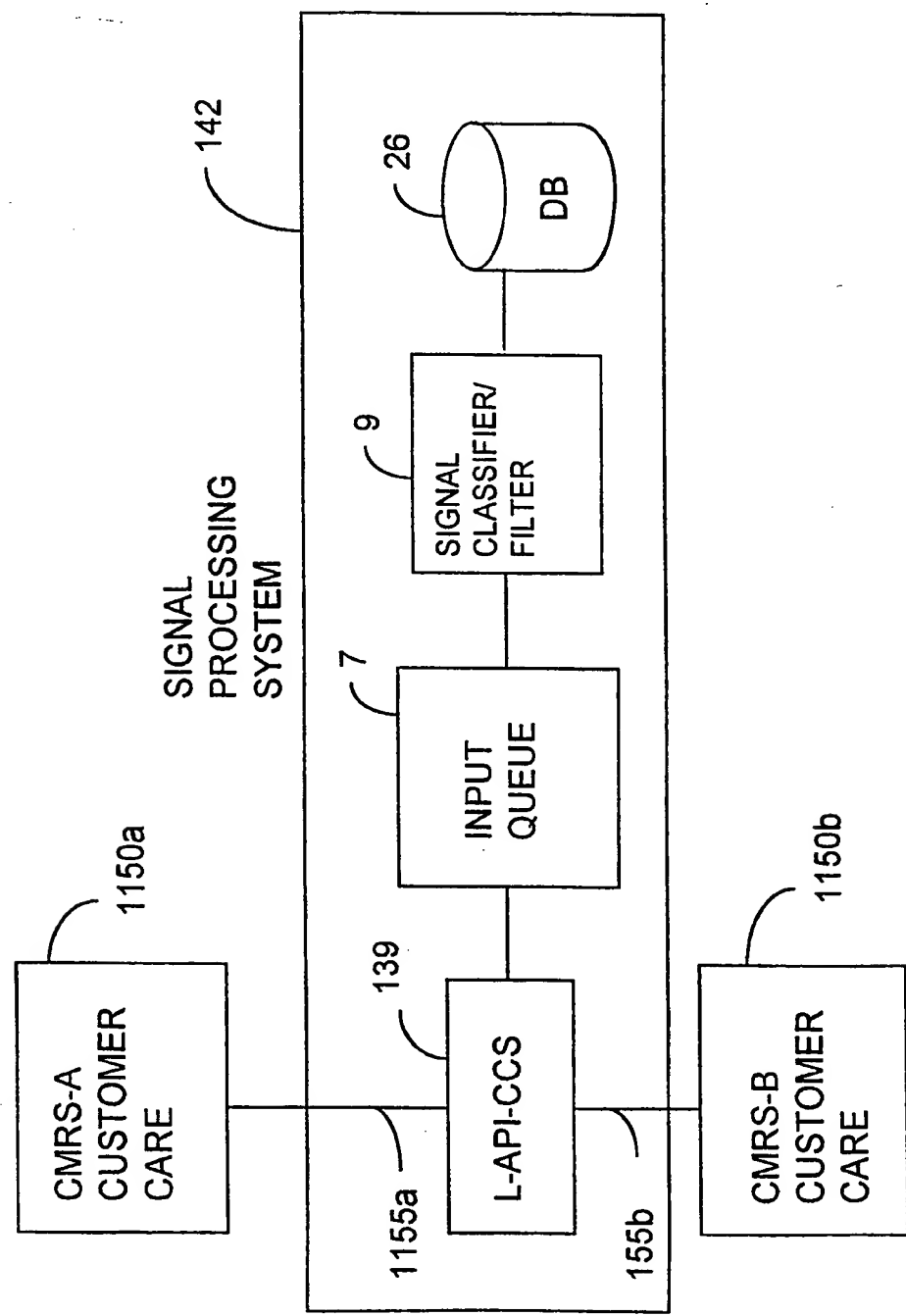


FIG. 31: LOCATION PROVISIONING VIA MULTIPLE CMRS